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Proposed Risk Management Guidance for the Permitting of New Stationary Diesel-Fueled Engines

California Environmental Protection Agency

Air Resources Board

Stationary Source Division
Emission Assessment Branch

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Guidance Prepared By:

Alexander J. Santos

Contributing Authors:

Grant Chin
Louis Chiu
Ron Hand
Robert Hughes
Peggy Jenkins
Lisa Jennings
Linda Keifer
Robert Krieger
Melanie Marty
Angus McPherson
Juli Sawaya
Tony Servin
Glen Villa
Lisa Williams

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I. Overview

A. What is the purpose of this document?

This document is the Air Resources Board (ARB/Board) staff's proposed guidance to assist local air pollution control districts and air quality management districts (districts) in making risk management decisions associated with the permitting of new stationary diesel-fueled engines. In the guidance, we specifically address the further control of diesel particulate matter (diesel PM) emissions from diesel-fueled engines. We suggest two options for diesel PM control; either compliance with diesel PM exhaust emission performance standards or compliance with minimum technology requirements for reducing diesel PM. We also suggest that a site-specific health risk assessment (HRA) be conducted and considered prior to issuing a permit for engines that operate extended hours. Appendix 4 provides a discussion of adjustments that may be used when performing the HRA.

It is important to note that the Guidance is a *non-regulatory* document that is a tool for districts to use in developing or modifying their new source permitting programs to address new stationary diesel-fueled engines. Nothing in our Guidance precludes districts from adopting different or more stringent requirements or from varying from the guidance to consider permit specific situations.

We also intend for the Guidance to serve as a starting point for developing an air toxic control measure (ATCM) for new stationary diesel-fueled engines. The control options presented in this guidance will be explored in much more detail during ATCM development, with emphasis given to establishing state-of-the-art engine certification levels, defining in-field compliance test methods, and researching the technological feasibility, durability, and costs of controls. Unlike the guidance, the ATCM will be a regulatory document and once adopted, districts will either be required to implement the ATCM or develop their own more stringent new stationary diesel-fueled engine rule.

B. How does the guidance presented in this document differ from the guidance presented in the ARB's Risk Management Guidelines for New and Modified Sources of Toxic Air Pollutants (Guidelines), July 1993?

The 1993 Guidelines suggest the use of a combination of specific risk levels and a risk action range to evaluate new and modified sources of toxic air pollutants. Specific risk levels are suggested for triggering the installation of toxic best available control technology (T-BACT) and for establishing an upper level maximum risk. A risk action range is suggested for providing flexibility when considering, in addition to risk, other factors such as site-specific meteorology, the proximity to residences, and potential impact on sensitive receptors. These 'other factors' are presented and discussed in a Specific Findings Report. The Air Pollution Control Officer (APCO) reviews this report and prepares findings supporting a decision to approve or deny the permit to operate.

The guidance presented in this document defines a technology-based approach that retains a risk-based review under certain conditions. The guidance suggests all new stationary diesel-fueled engines meet either minimum technology requirements or engine performance standards. For most engines, the permit to operate the engine is approvable once the appropriate minimum technology requirement or performance standard is met. For engines that operate more than 400 hours, we recommend that a site-specific HRA be required prior to permit approval. A discussion of the results of the HRA, as well as other factors, may be provided in a Specific Findings Report prepared by either the source or the district. The public then has an opportunity to review the Specific Findings Report and the proposed permitting action. The APCO then reviews the Specific Findings Report and the public's comments, and then prepares findings supporting a decision to approve or deny the permit to operate.

C. What are the key recommendations in this guidance?

The key recommendations in this guidance are:

- Approve permits for Group 1 diesel-fueled engines if they meet the appropriate performance standards or minimum technology requirements (see Table 1). We anticipate most (70%) new stationary diesel-fueled engines will fall in Group 1 based on the current inventory and average hours of operation of stationary diesel-fueled engines (ARB, July 2000). The current inventory includes agricultural engines, which are currently exempt from permitting requirements. Excluding agricultural engines, we anticipate that 90% of new stationary diesel-fueled engines requiring permits will fall in Group1. For these engines, meeting the appropriate minimum technology requirements or performance standards will result in the lowest achievable risk levels, in consideration of costs, uncertainty in the emissions and exposure estimates, and uncertainties in the approved health values. For these engines, a site-specific HRA is not required.

- Require a site-specific HRA prior to approval of diesel-fueled engines that fall within the Group 2 category (see Table 1). A site-specific HRA is needed to ensure that the lowest achievable risk levels will be achieved in consideration of costs, uncertainty in the emissions and exposure estimates, and uncertainties in the approved health values. We anticipate relatively few (30%) new stationary diesel-fueled engines will fall in Group 2 based on the current inventory and average hours of operation of stationary diesel-fueled engines (ARB, July 2000). As stated before, the current inventory includes agricultural engines, which are currently exempt from permitting requirements. Excluding agricultural engines, we anticipate that 10% of new stationary diesel-fueled engines requiring permits will fall in Group 2. For these sources, we believe a site-specific risk analysis needs to be

- completed prior to making a permitting decision. This approach is very similar to the action range approach presented in the 1993 Guidelines, where risks as well as other factors, such as location of sensitive receptors, are considered by the APCO prior to making a permitting decision. The significant difference between the approach in this guidance and the approach in the 1993 Guidelines is the lack of an upper level permit denial risk value. Rather than automatically denying any source with a risk greater than the upper level, we suggest the public be provided an opportunity to review and comment on the proposed permit action. The APCO would consider the public's comments in making the final permitting decision. We believe an upper level risk level would be too restrictive, not allowing for the approval of sources with well-controlled diesel-fueled engines that perform critical functions (i.e., emergency power generation) or for which there is no economically or technically feasible substitute.

- For Group 2 engines, conduct risk assessments consistent with the *California Air Pollution Control Officers Association (CAPCOA), Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines* (Risk Assessment Guidelines), dated October 1993[1], and the risk assessment guidance presented in Appendix 4 of this document. Use diesel PM as a surrogate for all toxic air contaminant emissions from diesel-fueled engines when determining the cancer risk and the noncancer hazard index for the inhalation pathway.

- Estimate risk using the Scientific Review Panel's (SRP) recommended unit risk factor of 300 excess cancers per million per microgram per cubic meter of diesel PM [$3 \times 10^{-4} (\mu g/m^3)^{-1}$] based on 70 years of exposure.[2]

- Consider the need for the project in addition to the uncertainty in the risk assessment information when making risk management decisions.

E. What is the statutory basis for developing this guidance?

The statutory authority for the ARB to develop this guidance document is found in Health and Safety Code (H&SC) sections 39605 and 39620(a). Section 39605 states that the ARB may provide assistance to any district. Section 39620(a) states that the ARB shall implement a program to assist districts in implementing permits. This

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[1] The Office of Environmental Health Hazard Assessment (OEHHA) is currently revising the CAPCOA Risk Assessment Guidelines. It is expected that districts will use the OEHHA risk assessment guidelines when completed later this year (2000).

[2] For Group 2 engines, the Specific Findings Report should also report the full range of risk identified by the SRP; 130 to 2400 excess cancers per million per microgram per cubic meter of diesel particulate matter. The unit risk factor of $3 \times 10^{-4} (\mu g/m^3)^{-1}$ is commonly expressed as 300 excess cancers per million per microgram per cubic meter of diesel particulate matter.

guidance provides assistance to districts for permitting new stationary diesel-fueled engines and is part of the ARB's program to assist districts in implementing permits. Further, the general authority for districts to control air pollution from all sources, other than emissions from motor vehicles, is found in H&SC section 40000.

This guidance document references the Risk Assessment Guidelines when defining how site-specific risk assessments should be conducted. However, the statutory authorities associated with the "Hot Spots" program, H&SC sections 44300 through 44394, should not be considered applicable to the implementation of this guidance.

II. Applicability

This section discusses the types of engines and fuels addressed by this guidance.

A. What types of diesel-fueled equipment are addressed by this guidance?

This guidance specifically addresses all new stationary, compression-ignition, internal combustion engines designed to use diesel fuel. This guidance does not address: 1) mobile equipment, 2) portable equipment, 3) military tactical support equipment, and 4) stationary and portable agricultural engines, 5) new construction and farming equipment less than 175 horsepower.

Mobile equipment, on-road and off-road vehicles, are not addressed in this guidance because they are not stationary equipment and are not required to obtain district operating permits.

Portable engines are engines that are designed and capable of being carried or moved from one location to another and do not remain at a single location for more than 12 consecutive months. Portable engines are not required to obtain a district operating permit if they are registered in the Statewide Registration Program. Since they are not required to obtain an operating permit, these engines are not addressed by this guidance.

Military tactical support equipment and stationary and portable agricultural equipment are exempted from permitting requirements through state law and are not addressed by this guidance. The Federal Clean Air Act also prevents states from regulating new construction and farm equipment with engines less than 175 horsepower.

In addition, we do not recommend using the health values contained in this guidance for assessing the risk from diesel-fueled equipment such as turbines, boilers, heaters, kilns, or flares.

B. Why are diesel-fueled turbines or external combustion engines not addressed in this guidance?

The health effects data used to develop the unit risk factor for diesel PM is based on compression-ignition (diesel cycle) engines. Currently, there is insufficient information to determine if the toxicity of particulate emissions from diesel-fueled turbines or external combustion engines (boilers, heaters, kilns, or flares) is significantly different from the toxicity of particulate emissions from diesel-fueled compression-ignition engines. As a result, we do not recommend using the health values contained in this guidance for permitting diesel-fueled turbines or external combustion engines, at this time. We will continue to evaluate the appropriateness of excluding turbines and external combustion engines as more data become available.

C. Are stationary compression-ignition engines using jet fuel addressed in the guidance?

Yes. Stationary, compression-ignition engines using jet fuel should be treated the same as stationary, compression-ignition engines using diesel fuel. Jet fuel has properties very similar to diesel fuel (i.e., sulfur content, cetane number, T-90 temperature, and aromatic content). Jet fuel can be used in compression-ignition engines without any significant adjustments to the engine. Because of the similarity in fuel properties and the ease of fuel switching, we believe treating new stationary compression-ignition engines using jet fuel or diesel fuel the same is appropriate and necessary.

III. Background

A. What action has the ARB taken concerning the identification of emissions from diesel-fueled engines as toxic air contaminants?

In August 1998, the ARB identified particulate matter emissions from diesel-fueled engines as a toxic air contaminant with no threshold exposure level. The Board approved the SRP's cancer unit risk factor of 130 to 2400 excess cancers per million per microgram per cubic meter of diesel PM. Final approval of ARB’s action by the Office of Administrative Law and the Secretary of State occurred in July 1999.

B. What are the uncertainties associated with the risk assessment?

The three main areas of uncertainty, which may underestimate or overestimate the risk from exposure to toxic air contaminants from diesel-fueled engines, are uncertainty in the emissions estimation techniques (emission factors and source test results); uncertainty in air dispersion modeling techniques used to assess exposure; and uncertainty in the techniques used to determine health risk values (cancer unit risk factor and the noncancer reference exposure level). The uncertainties in the emissions estimation techniques and in air dispersion modeling techniques are well known and discussed in numerous publications. The uncertainty in the techniques used to determine health risk values is discussed in more detail in Appendix 4. Appendix 4 contains excerpts from the Risk Assessment Guidelines and the *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part B, Health Risk Assessment for Diesel Exhaust.*

IV. Key Terms

A. **Diesel Fuel:** Fuel meeting the following specification

ASTM D975 – 98, Standard Specification for Diesel Fuel Oils; includes No. 1-D, No. 1-D low sulfur, No. 2-D, No. 2-D low sulfur, and No. 4-D.

B. **Jet Fuel:** Fuel meeting the following specification

ASTM D 1655 – 98, Standard Specification for Aviation Turbine Fuels; includes
Jet A, Jet A-1, and Jet B.

MIL-DTL-5624T, Turbine Fuel, Aviation, Grades JP-4, JP-5, and JP-5/JP8 ST.

MIL-T-83133D, Turbine Fuel, Aviation, Kerosene Types, NATO F-34 (JP-8) and NATO F-35; NATO F-35 similar to (JP-8).

C. **Diesel-Fueled Engine:** For purposes of this guidance, any internal combustion, compression-ignition (diesel cycle) engine that is fueled by diesel fuel or jet fuel.

D. **Emergency Standby Engine:** An internal combustion engine used only as follows: 1) when normal power line or natural gas service fails; or 2) for the emergency pumping of water for either fire protection or flood relief. An emergency standby engine may not be operated to supplement a primary power source when the load capacity or rating of the primary power source has been either reached or exceeded.

E. **New Diesel-Fueled Engine:** A new diesel-fueled engine is either:

1) A new diesel-fueled engine installed at a new or existing source. An exact replacement is considered the addition of a new diesel-fueled engine;
2) A diesel-fueled engine relocated from an off-site location; or
3) A reconstructed diesel-fueled engine, where the cost of reconstruction is greater than or equal to 50% of the purchase price of a new similarly sized engine (basic equipment only).

F. **Catalyst-based DPF:** A DPF that incorporates a catalyst or an uncatalyzed DPF that incorporates a fuel-borne catalyst to effectively lower the soot burn-off temperature.

V. The Basic Approach

The basic approach consists of two options: 1) complying with minimum technology requirements; or 2) complying with performance standards.

A. Minimum Technology Requirement Option

1) *Since diesel PM has been identified as a non-threshold carcinogen, we are suggesting in this guidance that any new stationary diesel-fueled engine meet the most stringent particulate matter certification level that is currently being met by a similar engine.*

In determining the most stringent particulate matter certification level that is currently being met, we looked at both on-road and off-road certification data. Comparison of on-road and off-road standards is not straightforward, since off-road test procedures are done in accordance with International Standards Organization (ISO) 8178 steady-state test procedures and on-road diesel-fueled engines are tested in accordance with Federal Test Procedures (FTP) transient test cycles. The limited engine test results we have seen show that an engine tested on both transient and steady-state test cycles will generally show a lower diesel PM emission rate during the steady-state test cycles. Therefore, we are assuming that an engine that can meet an on-road certification level (transient test) will meet a similar off-road certification level (steady-state test).

2) *We are suggesting in this guidance that add-on control equipment be required on new stationary diesel-fueled engines, in consideration of engine size, cost, operating scenario, and technical feasibility.*

In general, engines that are operated for extended periods of time emit the most diesel PM and pose the greatest risk. We have conducted air dispersion modeling analysis varying the horsepower and annual hours of operation for representative stationary diesel-fueled engines operating in California. We have analyzed the results of our modeling efforts and we recommend that add-on controls be required on all engines that are greater than 50 horsepower.

Add-on control equipment being used in on-road diesel engine applications is expected to be utilized in off-road stationary diesel-fueled engine applications. We recommend catalyst-based diesel particulate filters (DPFs). Some unique aspects of the operating environment or performance requirements of an off-road engine may govern the application of the control equipment. For example, particulate traps generally require engine exhaust to meet a certain temperature to facilitate filter regeneration. An off-road diesel-fueled engine that operates at a low load and cyclical speeds may not generate an exhaust temperature that is sufficient to regenerate the filter, even when the filter is catalyzed. For these cases, an electrically powered heater for filter regeneration may be the preferred option. Electrically regenerated DPFs are not as effective in reducing diesel PM. However, an electrically regenerated DPF used in tandem with an oxidation catalyst may reduce diesel PM as much as a catalyst-based DPF. We believe, in almost all situations, that DPFs are both technically and economically feasible for new engine applications.

3) *We are suggesting in this guidance that very low-sulfur CARB diesel fuel be used in new stationary diesel-fueled engines.*

Add-on control equipment that incorporates a catalyst may generate sulfate particles when high sulfur diesel fuel is used. The increase in sulfate particles may offset the reduction in other particulate matter species. To limit this effect, we are suggesting that very low sulfur content diesel fuel be used. CARB diesel currently limits sulfur content to 500 ppmw. Currently, some refiners are marketing diesel fuel with a sulfur content below 15 ppmw. We are suggesting that where available, owners/operators of stationary diesel fueled engines use CARB diesel with sulfur contents below 15 ppmw.

4) *We are suggesting in this guidance that a site-specific HRA be conducted on diesel-fueled engines that are greater than 50 horsepower and operate over 400 hours a year to ensure the lowest achievable risk level will be achieved, in consideration of cost and technical feasibility of control.*

Our air dispersion modeling results indicate that diesel-fueled engines operated over 400 hours per year may result in nearby receptors being exposed to elevated levels of diesel PM. HRA results, as well as other site-specific findings such as the location of sensitive receptors, should be considered when permitting these engines. We suggest that the public be allowed to review and comment on the proposed permit action prior to the district's final decision.

B. Performance Standard Option

1) We are suggesting in this guidance that owner/operators be allowed to meet a performance standard in lieu of meeting the engine certification/add-on control/very low-sulfur CARB diesel requirements.

The performance standards identified in the guidance are based on the anticipated diesel PM reductions achieved by engines meeting the engine certification/add-on control/low sulfur CARB diesel requirements.

VI. Permitting Requirements

This section identifies and discusses the suggested minimum technology requirements for permitting new or relocated diesel-fueled engines operating at stationary sources. The suggested minimum technology requirements are based on current engine, add-on control, and fuel technologies. These requirements will need to be reevaluated if engine certification standards or diesel fuel specifications change significantly. Table 1 summarizes these requirements.

Table 1: Permitting Requirements for New Diesel-Fueled Engines

Engine Category	**Annual Hours of Operation**	**Group**	**Minimum Technology Requirements**				**Additional Requirements**	
			Performance Standard[1] (g/bhp-hr)	New Engine PM Emission Certification Levels[1] (g/bhp-hr)	Fuel Technology Requirements	Add-On Control	HRA Requirement	SF Report
Engines ≤ 50 hp	All	1	0.2	0.2	CARB Diesel or equivalent	No	No	No
Engines > 50 hp	≤ 400 hours	1	0.02	0.1	Very low-sulfur CARB Diesel or equivalent [2]	Catalyst-based DPF or equivalent	No	No
	> 400 hours	2	0.02	0.1	Very low-sulfur CARB Diesel or equivalent [2]	Catalyst-based DPF or equivalent	Yes	If HRA shows risk > 10/million

HRA - Health Risk Assessment; SF - Specific Findings; DPF - Diesel Particulate Filter

[1] ISO 8178 test procedure IAW *California Exhaust Emission Standards and Test Procedures for New 1996 and Later Off-Road Compression–Ignition Engines, May12, 1993.*
[2] Very low sulfur (≤ 15 ppmw) CARB diesel or equivalent is only required in areas where the district determines it is available in sufficient quantities and economically feasible to purchase. CARB diesel is required to be used in all other areas.

We have established two categories of stationary diesel-fueled engines: engines with horsepower ratings equal to or less than 50 and engines with horsepower ratings greater than 50. We know from reviewing air dispersion modeling results that engine horsepower, or size, does not have as significant an impact on the maximum risk as does the diesel PM emission certification level and the hours of operation. (See Appendix 2 for more details.) Therefore, we recommend permitting requirements for diesel-fueled engines that are the same for all engine sizes, with the exception of engines less than or equal to 50 horsepower. However, we recommend slightly more stringent permitting requirements for diesel-fueled engines that operate in excess of 400 hours annually

For new stationary diesel-fueled engines greater than 50 horsepower, we suggest using very low-sulfur ($\leq$ 15 ppmw) CARB diesel or an equivalent fuel, where available. All diesel fuel sold or supplied in California for motor vehicle use (CARB diesel) must have a sulfur content of 500 ppmw or less. Currently stationary engines are exempt from meeting CARB diesel requirements, but may be required under local district rule to use CARB diesel. We believe all stationary diesel-fueled engines should be required to use CARB diesel. Further, where available in sufficient quantities, we believe districts should require stationary diesel-fueled engines to use CARB diesel with sulfur contents $\leq$ 15 ppmw. A sulfur content of 15 ppmw or less allows catalytic after treatment technologies to function more efficiently and reliably. In CARB's recently adopted regulation for a public transit bus fleet rule, transit agencies will be required to purchase very low-sulfur CARB diesel fuel with a cap of 15 ppmw beginning July 1, 2002. In-field compliance sampling and analysis indicates that diesel fuel meeting the 15 ppmw sulfur content requirement has already been marketed in California for general use.

The following paragraphs discuss in more detail the two categories of diesel-fueled engines and the basis for the new engine particulate matter certification levels, add-on control requirements, and performance levels. A detailed discussion of the suggested process for making permitting decisions is contained in Section VII, Approval Process.

A. Engines $\leq$ 50 horsepower

1. Description

A majority of the engines $\leq$ 50 horsepower (small engines) used throughout the state are used in mobile and portable applications, (i.e., skid-steer loaders, commercial turf mowers, portable generator sets, and portable compressors). Currently, small stationary engines are exempted from most district permitting requirements, so we do not have an accurate estimate of how many are currently operating in the state. From the limited information we have, we estimate small stationary diesel-fueled engines comprise less than 10% of the small engines operated in the state (ARB, January 2000).

2. New Engine Certification Levels

Assuming that stationary diesel-fueled engines 50 horsepower or less make up a very small percentage of the stationary diesel-fueled engine inventory, the impact of controlling the diesel PM emissions from small engines may not be great. However, given the classification of diesel PM as a nonthreshold carcinogen, we believe minimum technology requirements should be required for all new sources of diesel PM, including small engines. We suggest the minimum technology requirements for new stationary small engines should be equal to: 1) the most stringent PM certification level currently being met by similar engines, and 2) the use of CARB diesel. We have data that shows that some engines 50 horsepower or less are currently meeting 0.2 g/bhp-hr (steady-state) certification levels (U.S. EPA*,* August 8, 1997*).*

3. Add-on Controls

No add-on controls are suggested for small engines.

4. Performance Standard

The performance standard for small engines is 0.2 g/bhp-hr, which is equivalent to the lower end of the range of new engine PM certification levels.

B. Engines > 50 horsepower

1. Description

This category includes all stationary diesel-fueled engines with horsepower ratings greater than 50 horsepower. There is a multitude of uses for engines in this category. Typically, stationary diesel-fueled engines are used in the following types of applications: cranes, pumps, welding, woodchippers, power generation, compressors, and rockcrushing.

This category also addresses emergency standby engines. Emergency standby engines are used to either provide emergency electrical power or the emergency pumping of water for flood relief or fire protection. Several types of facilities are required to have standby engines to provide emergency power systems. These include hospitals, airports, correctional facilities, city sewage, and water plants. Many large office buildings and apartment complexes also have emergency standby engines. Emergency standby engines can range from 50 horsepower to over 1000 horsepower.

Currently, most districts exempt emergency standby engines from new source permitting requirements. We suggest that permitting rules include emergency standby engines since a significant amount of diesel PM emissions can be emitted during maintenance operations. Many facilities with emergency standby engines are required to conduct maintenance runs to ensure the operational readiness of the engine. Typical maintenance runs are conducted at minimal load and can last from five minutes to two hours. The frequency of maintenance runs can vary from once a year to once every seven days. ARB estimates that emergency standby engines comprise approximately 70% of the stationary diesel-fueled engines located throughout the state and emit approximately 140 tons of diesel PM a year. (ARB, July 2000)

2. New Engine Certification Level

We suggest that new permits for stationary diesel-fueled engines rated at 50 horsepower or greater require the applicant to use engines certified to meet a PM emission standard of 0.1 g/bhp-hr over a steady-state test cycle (ISO 8178). We base this suggestion on existing PM emission standards and engine certification data for model year 1999 and 2000 engines.

Table 2: California Diesel Engine Particulate Matter (PM) Emission Standards
(1991 to 2006 & Later)

Category	**Engine Rating**	**PM Emission Standard**															
	hp	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006 & later
Passenger cars and light-duty trucks*	120-200	0.08 g/mile		0.08 g/mile (TLEV &LEV)												0.04 g/mile (TLEV)	
(continued)	120-200	NA		0.04 g/mile (ULEV)												0.01 g/mile (LEV,ULEV,SULEV)	
Medium-duty*	200-300	NA	0.1 g/bhp-hr (LEV & ULEV)														
(continued)	200-300	NA				0.1 g/bhp-hr (Tier I)											
(continued)	200-300	NA					0.05 g/bhp-hr (SULEV)										
Heavy-duty*	250-500	0.25 g/bhp-hr			0.1 g/bhp-hr												
Off-road	0-11	NA					0.9 g/bhp-hr				0.75 g/bhp-hr					0.6 g/bhp-hr	
(continued)	11-25	NA					0.9 g/bhp-hr				0.6 g/bhp-hr						
(continued)	25-50	NA								0.6 g/bhp-hr					0.45 g/bhp-hr		
(continued)	50-100	NA													0.3 g/bhp-hr		
(continued)	100-175	NA												0.22 g/bhp-hr			
(continued)	175-300	NA					0.4 g/bhp-hr							0.15 g/bhp-hr			
(continued)	300-600	NA					0.4 g/bhp-hr					0.15 g/bhp-hr					
(continued)	600-750	NA					0.4 g/bhp-hr						0.15 g/bhp-hr				
(continued)	>750	NA									0.4 g/bhp-hr						0.15 g/bhp-hr
Urban Bus Engines*	250-300	0.1 g/bhp-hr			0.07 g/bhp-hr										0.01 g/bhp-hr		

*Transient Test

Note: Table does not include optional standards for heavy-duty vehicles or urban bus engines.
Table is supplied for comparison purposes only. Refer to regulations for compliance questions.

Table 2 lists the existing California diesel engine emission standards for both on-road and off-road diesel-fueled vehicles and engines. As shown in Table 2, the most stringent off-road engine PM emission standards for diesel-fueled engines greater than 50 horsepower for the year 2000 range from 0.60 to 0.15 g/bhp-hr, depending on the engine's horsepower rating.

However, for engines in the 200-500 horsepower range, the year 2000 on-road PM emission standards are significantly more stringent than the comparable off-road standards (0.1 g/bhp-hr as compared to 0.4 g/bhp-hr). As mentioned previously, the on-road standards are FTP transient test certification levels while the off-road standards are ISO 8178 steady state certification levels. The limited engine test information we have seen indicates that an engine that is certified to 0.1 g/bhp-hr via a transient test would certify to less than 0.1 g/bhp-hr via a steady-state test. This supports our suggestion that a 0.1 g/bhp-hr (steady-state) standard certification level is achievable by engines within the 200-500 horsepower range.

Similarly, we believe a standard of 0.1 g/bhp-hr (steady-state) is appropriate for stationary diesel-fueled engines within the 120-200 horsepower range based on current on-road standards. On-road diesel-fueled vehicles equipped with engines in the 120-200 horsepower range must comply with 0.08 and 0.04 gram/mile emission standards. These vehicles are tested on a vehicle chasis dynamometer. The 0.08 and 0.04 gram/mile vehicle standards are roughly equivalent to the 0.1 and 0.05 g/bhp-hr transient engine test standards, respectively. Further, for diesel-fueled engines between 50 and 800 horsepower, we have U.S. EPA Non- road Engine Certification Data that shows some model year 1999 and 2000 diesel-fueled engines are currently meeting 0.04 to 0.13 g/bhp-hr (steady-state) certification levels.

3. Add-on Control

We suggest that stationary diesel engines greater than 50 horsepower be required to install a catalyst-based DPF or equivalent control technology. DPFs are exhaust treatment devices that have shown through testing and in-use applications to be effective at reducing PM emissions. In general, a properly sized and installed DPF can reduce PM emissions by 70% or more.

4. Performance Standard

We suggest that stationary diesel-fueled engines greater than 50 horsepower meet a performance standard of 0.02 g/bhp-hr. The 0.02 standards are based on the anticipated PM emission levels from new stationary diesel-fueled engines meeting the proposed certification levels, using very low-sulfur ($\leq$ 15 ppmw) fuel, and incorporating a catalyst-based DPF. In general, a properly sized and installed catalyst-based DPF can reduce PM emissions about 85% when used with very low sulfur fuel.

5. Diesel Particulate Filter (DPF)

DPFs reduce PM emissions by trapping the particles in a flow filter substrate where it is oxidized, or burned-off, once the filter reaches a certain temperature. This burn-off process is referred to as filter regeneration. DPFs remove the solid, dry carbon (soot) from the exhaust stream. DPFs also reduce carbon monoxide (CO) and hydrocarbon emissions, if catalyzed.

For most applications, passive regeneration of the filter at exhaust temperatures is difficult to achieve during normal operating conditions. For this reason, most DPFs incorporate a catalyst that effectively lowers the soot burn-off temperature. Most DPF manufacturers apply a catalytic coating directly to the filter element, others manufacture systems that incorporate a fuel-borne catalyst or electrically powered heating units used in conjunction with an uncatalyzed filter. Catalyzed DPFs, fuel-borne catalysts, and electrically regenerated DPFs are discussed in more detail in Appendix 1. The catalyst not only promotes the burn-off of soot, but also reduces the soluable organic fraction (SOF), hydrocarbons (HC), and CO.

The formation of sulfate particles increases at higher temperatures and with the presence of sulfur in the fuel. This effect can be minimized by using diesel fuel with very low sulfur content.

Steady-state emissions testing of older diesel-fueled engines equipped with catalyst-based DPFs have shown overall reduction in diesel PM of up to 85%. Transient tests of a hybrid diesel-electric engine and of a diesel-fueled engine used in a wheel loader application have shown reductions in diesel PM of 92% and 97%, respectively. The results of the Manufacturers of Emission Controls Association (MECA) study indicate that a catalyst-based DPF can reduce emissions at least 70% while using a fuel with a sulfur content of 368 ppmw. Because electrically regenerated DPFs do not typically incorporate catalyst material, ARB staff expect lower control efficiencies than the catalyst-based DPF. Reduction of the SOF of diesel PM is increased in the presence of a catalyst.

Table 3 provides information on the estimated capital and annualized costs associated with retrofitting stationary engines with catalyst-based DPFs (catalyzed DPFs or uncatalyzed DPFs used with a fuel-borne catalysts.) For comparison, the table also provides similar information on the estimated costs for new engines. The range in capital costs was obtained from representative manufacturers, and is intended to represent the range in the retail costs at this time. For stationary engines 100 horsepower and larger, the catalyst-based DPF capital cost is consistent with the $30 to $50 per horsepower range reported by the MECA in “Emission Control Technology for Stationary Internal Combustion Engines” dated July 1997.

Table 3: Costs of Catalyst-Based DPFs and New Engines					
Technology	**40 hp**	**100 hp**	**275 hp**	**400 hp**	**1,400 hp**
C-DPF[3]					
Capital Cost	\$3,300 - \$5,000	\$5,000 - \$7,500	\$6,900 - \$9,000	\$10,500	\$32,000 - \$44,000
Annualized Cost[4]	\$720 - \$1,200	\$1,030 - \$1,630	\$1,430 - \$1,970	\$2,070 \$2,280	\$6,060 \$8,140
New Engine					
Capital Cost[5]	\$4,290	\$6,960 - \$18,840	\$12,440 - \$32,150	\$23,100 - \$48,370	\$186,890
Annualized Cost	\$1,040	\$1,770 - \$3,620	\$2,480 - \$5,970	\$4,910 - \$8,850	\$32,800

VII. Approval Process

A. Overview

This section identifies the suggested approach for permitting new stationary diesel-fueled engines. As discussed in the previous section, we are suggesting grouping all stationary diesel-fueled engines into two broad categories: engines with horsepower ratings 50 horsepower or less and engines with horsepower ratings greater than 50 horsepower. The source would identify the appropriate category for the engine they plan to install and the maximum number of hours a year the engine will operate.

Minimum technology requirements or performance standards would be required to be met before a permit is approvable[6]. These requirements are summarized in Table 1. For engines that will operate over 400 hours a year, a site-specific HRA must be completed prior to the district approving the permit. A Specific Findings (SF) report would also be required if the HRA shows the cancer risk from the engine is greater than 10 excess cancers per million. Engines whose permits would be approvable without a site-specific HRA being prepared are referred to in this report as Group 1 engines. Engines for which the district requires an HRA be prepared are referred to as Group 2 engines. The following text and Figure 1 describe in more detail the suggested approach for permitting new stationary diesel-fueled engines.

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[3] Catalyst-based DPFs require the use of very-low sulfur diesel fuel. The incremental cost of this fuel is projected to be less than \$ 0.05 per gallon and is discussed further in Appendix IV.
[4] Annualized cost estimates include capital costs, installation costs, maintenance costs and operating costs, and they are based on an interest rate of 9% and a maximum economic life of 10 years. The incremental cost associated with using very-low sulfur fuel is not included in the operating cost estimates.
[5] Capital cost estimates for new engines are based on information provided by engine suppliers and data submitted with applications for the Carl Moyer incentive program.
[6] Assuming source meets all other district requirements and all applicable state or federal requirements.

It is important to note that this Guidance does limit a district's ability to develop a permitting program for stationary diesel fueled engines that differs from our suggested approach. From our meetings with districts, we anticipate that some districts will adopt new stationary diesel-fuel engine permitting rules that differ from our suggested approach in the following areas:

- Require existing diesel-fueled engines that increase their permitted diesel PM emission levels to use CARB diesel fuel (very low sulfur ($\leq$ 15 ppmw) where available) and apply add-on controls.

- Have the option to require an HRA at any point in the permitting process.

- Have the option to require more stringent minimum technology requirements and performance standards

Figure 1. Conceptual Decision Flow Chart for Permitting New Stationary Diesel-Fueled Engines

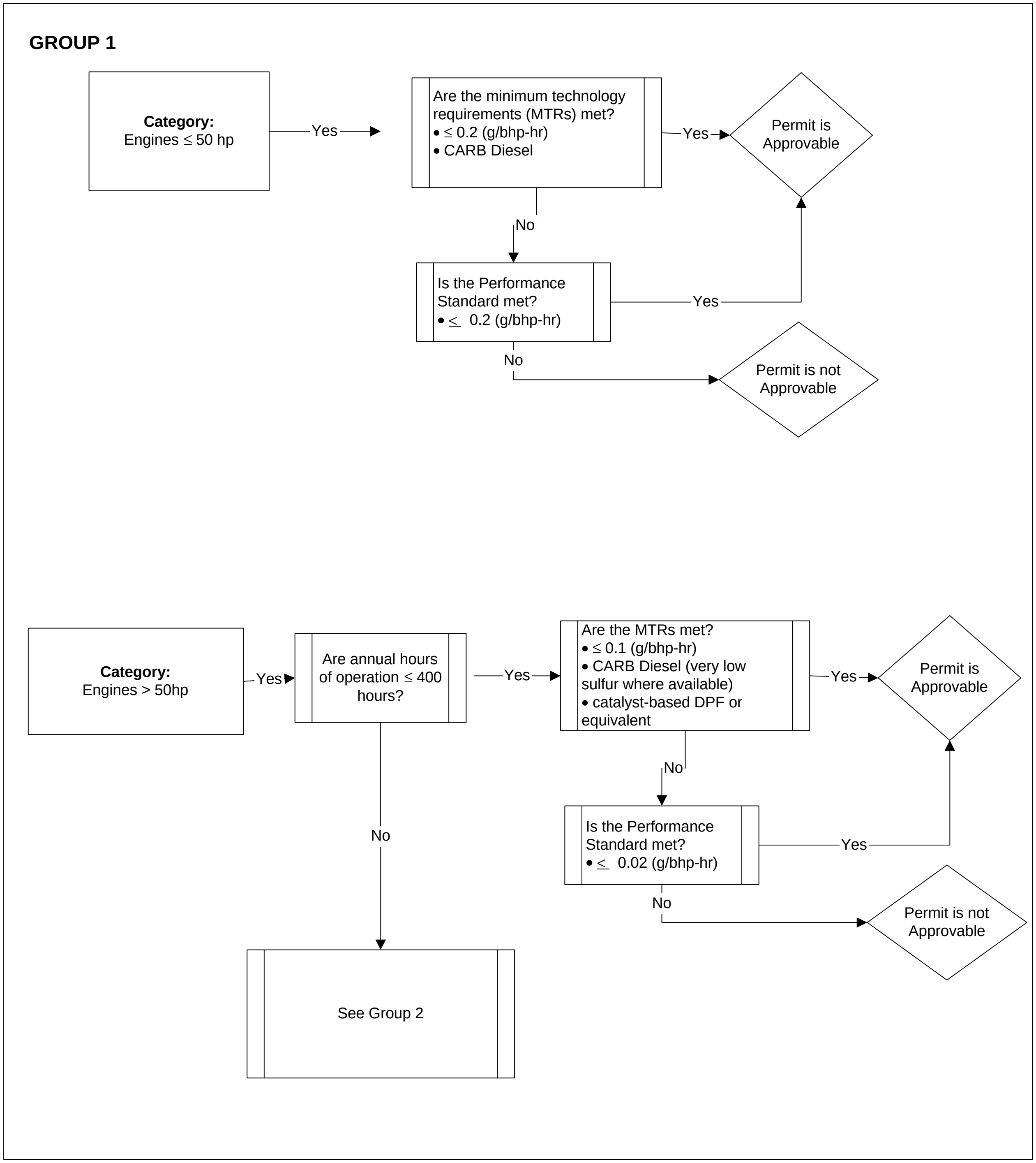
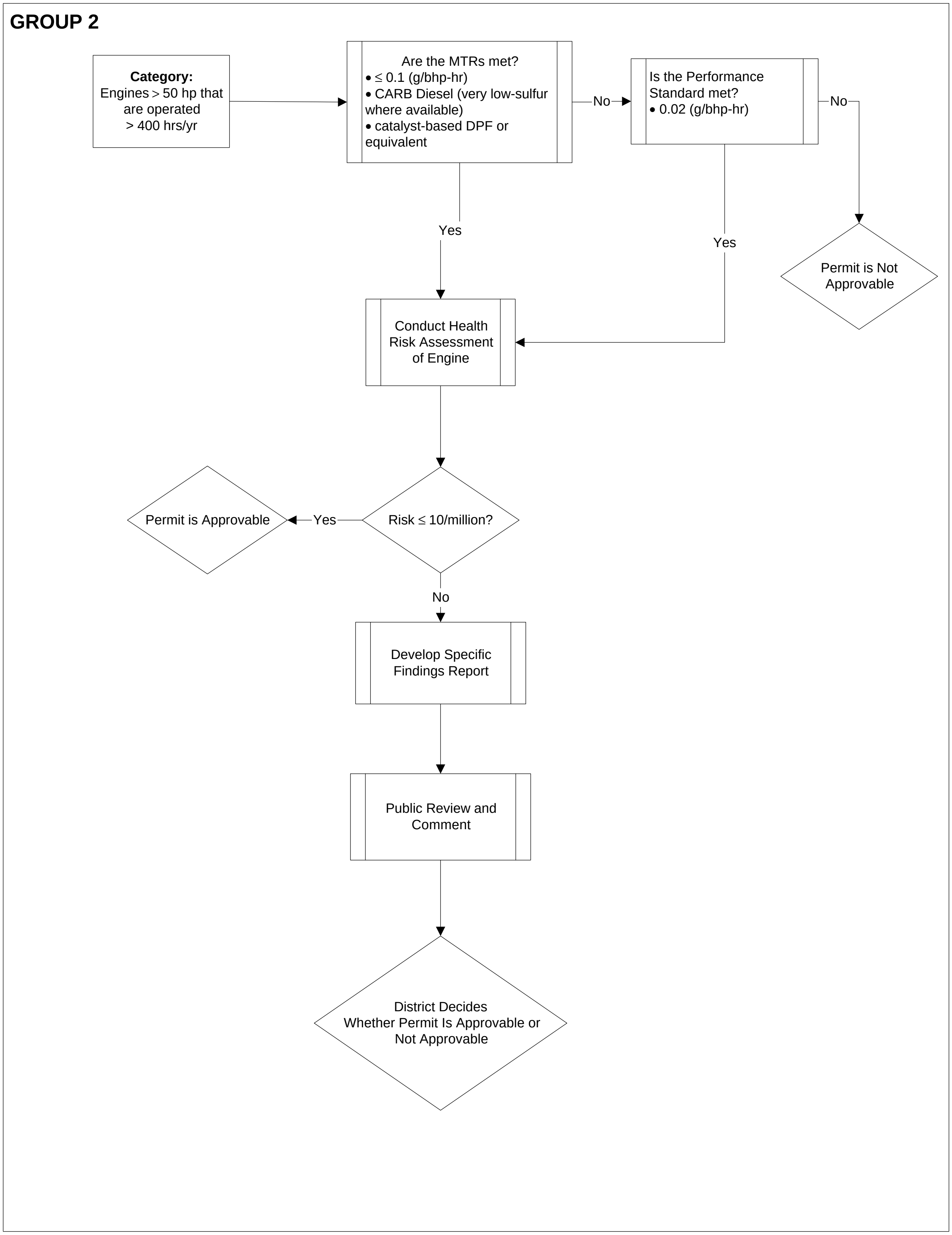


Figure 1 (continued)



B. Tiered Approach

All diesel-fueled engines required to obtain a district operating permit fall into one of two groups of categories, Group 1 or 2.

We suggest that engines from Group 1 categories be approved if they meet or exceed the appropriate minimum technology requirement or performance standard. We believe that most permitted stationary diesel-fueled engines will be Group 1 engines. Group 1 includes all engines with horsepower ratings less than or equal to 50 and all engines with horsepower ratings greater than 50 that are operated 400 hours a year or less (see Table 1). For emergency standby engines, the annual hours of operation are defined as the scheduled hours the engine is operated to insure its readiness in times of emergency.

Group 2 engine categories represent those stationary diesel-fueled engines operated more than 400 hours per year. (See Table 1.) Engines from the Group 2 category are required to meet or exceed the appropriate minimum technology requirements or performance standard and perform a site-specific screening HRA. Based on the screening HRA, the district can then determine if a more detailed analysis or a Specific Findings Report will be necessary. Criteria for determining if a more detailed analysis or a Specific Findings Report is necessary includes factors such as:

- availability of electricity or natural gas (note: not applicable to emergency standby engines);
- proximity of sensitive receptor location, i.e., school or daycare center;
- existing risk posed by facility;
- multiple engines being installed at the same location;
- screening HRA that shows the potential cancer risk from diesel PM emissions from the engine is significant (e.g., diesel PM inhalation cancer risk is greater than 10 in a million); or
- availability of cleaner diesel fuel.

The screening HRA need only evaluate the inhalation cancer risk posed by the emissions of diesel PM from stationary diesel-fueled engines. In identifying diesel PM emissions as a toxic air contaminant, the SRP recommended a reasonable unit cancer risk (300 excess cancers per million per $\mu g/m^3$) when determining the cancer risk from inhalation, and a reasonable exposure level (REL) of 5 $\mu g/m^3$ when evaluating chronic noncancer risk. An acute noncancer risk REL was not recommended at this time, however acute RELs for several of the TACs found in the diesel exhaust have been approved by the SRP. Therefore, cancer risk from inhalation of PM and noncancer risk, as expressed as a hazard index value, from diesel PM (chronic) and from other TACs which are found in diesel exhaust (acute) can be estimated.

Our analysis shows that the cancer risk from inhalation is the critical path when comparing cancer and noncancer risk. In other words, a cancer risk of 10 per million from the inhalation of diesel PM will result from diesel PM concentrations that are much less than the diesel PM or TAC concentrations that would result in chronic or acute noncancer hazard index values of 1 or greater.

For engines requiring a more detailed analysis and Specific Findings Report, we suggest allowing the public to review and comment on the proposed permitting action. The type of information needed for a more detailed analysis is presented in the following section.

C. Detailed Analysis - Specific Findings Report

This section only applies to Group 2 categories of engines. We suggest that the district review site-specific information when making a permitting decision for a Group 2 engine. Listed below are examples of the type of information we believe should be reviewed by the district. The district's analyses can be discussed and summarized in a Specific Findings Report, which can be made available to the public for review and comment.

The following information may be included in the Specific Findings Report:

- An evaluation of the technical and economic feasibility using cleaner diesel fuel or a non-diesel-fueled (i.e., electric or natural gas) engine.

- A site-specific HRA of the stationary diesel-fueled engine(s). The OEHHA is currently developing risk assessment guidelines that when complete, should be used when conducting site-specific risk assessments. Until the OEHHA completes its work on the guidelines, we believe that risk assessments should be done in accordance with the most current version of the *CAPCOA Air Toxics "Hot Spots" Program Risk Assessment Guidelines*. Appendix 4 of this guidance, Adjustment to the Risk Assessment Methodology, identifies adjustments that can be made in conducting risk assessments of stationary diesel-fueled engines.

- An evaluation of site-specific design considerations that would be employed to minimize the impact of particulate matter emissions from stationary diesel-fueled engine(s) on near source receptors. Table 3 presents a list of possible options.

Table 3: Source Design Options	
Optimizing diesel engine stack height	Maximizing buffer zones via diesel engine location
Operating at times of day that have the least impact	Locating engine to take advantage of meteorology
Non-full load testing	Inspection/maintenance program

- An evaluation of the technical and economic feasibility of emission reduction options that would provide particulate emission reductions beyond the minimum technology requirements.
- An evaluation of the technical and economic feasibility of emission reduction options that are likely to be available in the next three years which would provide particulate emission reductions beyond the minimum technology requirement.
- An evaluation of the risk contributed by other proposed or existing diesel-fueled engines at the source.
- An evaluation of the risk contributed by other non-diesel-fueled equipment at the source.
- A facility-wide risk assessment.
- A discussion of the uncertainty associated with the emissions, exposure, or risk estimates.
- A discussion of the benefits associated with the proposed project.
- A discussion of any existing federal, state, or local mandates that require the proposed project.
- A discussion of facility risk relative to ambient levels.
- A discussion of the impacts of the proposed project on media other than air.

The date when public comments on the Specific Findings Report are due to the district and the date when the final permitting decision is to be made should be included in the Specific Findings Report. If the district is planning to conduct a public meeting to discuss the proposed permitting action and Specific Findings Report, information on when and where the meeting or meetings will be held should be included in the Specific Findings Report.

D. Evaluation of Alternatives to Add-On Control Requirements

The suggested minimum technology requirements for diesel-fueled engines require that a catalyst-based DPF, or equivalent, add-on control technology be installed on diesel-fueled engines that meet certain horsepower and annual hours of operation criteria. We suggest a PM emission reduction of 70% or greater be demonstrated. We believe a 70% reduction is achievable based on: 1) the average diesel PM reduction of the catalyzed DPF emission tests summarized in Appendix 1 (91% reduction); 2) the diesel PM reduction of an uncatalyzed DPF as reported in SAE Technical Paper # 1999-01-0110 (79% reduction); and 3) the diesel PM reductions reported in the MECA study, which tested both catalyzed and uncatalyzed DPFs used in conjunction with fuel-borne catalysts (77% reduction).

In order to insure that the diesel PM emission reductions associated with the alternative add-on control technology meet or exceed the 70% emission reduction criteria, we suggest that the diesel-fueled engine and alternative control be source tested. Appendix 3 is a draft source test protocol that was developed by the ARB to test the effectiveness of two DPFs at a specified source. The section of the protocol that evaluates the effectiveness of add-on control equipment is applicable here. The source test requires the diesel-fueled engine to be run at speeds and loads that would reflect the engine's operating scenario. The source test protocol involves collecting diesel PM emissions samples from the engine's exhaust stream before and after the add-on control technology. The percent reduction of diesel PM emissions resulting from the alternative add-on control equipment can then be calculated using the sampled diesel PM emissions. This calculated diesel PM percent reduction would then be compared to the 70% PM emission reduction criteria to determine if the alternative is approvable.

Another important consideration when choosing an alternative control technology is the control technology's effect on NOx emissions. Alternative control technologies should not be approved if they result in a NOx emission rate that exceeds the engine's certification level.

VIII. References

ARB, *Public Meeting to Consider Approval of California's Emissions Inventory for Off-Road Large Compression-Ignited Engines (CI) (>25 hp), Table 5: Light-Duty Commercial Equipment Breakdown Percentages,* January 2000.

ARB, *Proposed Risk Management Plan for Diesel-Fueled Engines and Vehicles, Appendix II, Table 2: Stationary Diesel-Fueled Engines Current NOx and Diesel PM Emission Estimates,* July 2000*.*

U.S. EPA , *Certifcation Data for Nonroad Diesel Engines,* memorandum from Phil Carlson to Docket A-96-40*,* August 8, 1997

APPENDIX 1

Catalyzed Diesel Particulate Filter, Fuel-borne Catalyst, and
Electrically Regenerated Particulate Filter
Control Technology Evaluations

Control Technology Evaluation

Item	Response
Technology:	Catalyzed Diesel Particulate Filter
Technology Description: (How does it work?)	The technology is a passive, self-regenerating catalyzed diesel particulate filter (C-DPF). The technology reduces particulate matter, carbon monoxide and hydrocarbon emissions through catalytic oxidation and filtration. The C-DPF collects diesel particulate matter and oxidizes it during hot duty cycle operations. (This process of cleaning the C-DPF is called regeneration.) Typically, the filter media consists of ceramic wall-flow monoliths which capture the diesel particulates. These ceramic monoliths are either coated with a catalyst material or a separate catalyst is installed upstream of the C-DPF. The catalyst reduces the temperature at which the collected particulate matter oxidizes, and it oxidizes the soluble organic, carbon monoxide and hydrocarbon emissions.
Applicability: (What types of engines can the product be installed on?)	The technology is available for stationary and portable diesel engines rated at 5,000 horsepower or less and can be retrofitted to existing equipment. However, the technology is not appropriate for an application where an engine and its associated duty cycle do not generate enough heat to oxidize the collected particulate matter and regenerate the filter. For example, C-DPFs may not be appropriate for engines used in severe cyclic operations.
Achieved Emission Reductions:	**Product** / **Test Cycle** / **PM Reduction** Nett SF Soot Filter / CBD Transient / 92% Engelhard DPX / Special Transient / 97% CleanDiesel Soot Filter / ISO 8178 C1 / 85%
Emission Reduction Guarantee:	The emission reduction efficiency of this technology depends on the associated engine's baseline emissions, fuel sulfur content and emission test method / cycle. As such, diesel particulate filter manufacturers do not provide emission reduction guarantees.
Costs: Initial Retail:	The initial cost is: \$3300 - \$5000 for a 40 hp engine; \$5000 - \$7500 for a 100 hp engine; \$6900 - \$9000 for a 275 hp engine; \$10,500 for a 400 hp engine; and \$32,000 - \$44,000 for a 1,400 hp engine.
Installation:	\$167 - \$518 (Assuming 1.5 - 6 hours x \$78/hr + \$50 in misc parts.)
Operating:	Fuel consumption may increase by one to one and a half percent due to additional backpressure.
Maintenance:	\$156 - \$312 (Assuming 2 - 4 hours labor per year.)
Comments:	Diesel particulate filters should be cleaned regularly. Because of their higher backpressures (e.g. 20 – 70+ in. wc.) and the potential for masking by lube oil ash, ARB staff expect that the periodic maintenance of DPFs will be necessary. ARB staff expect that the maintenance costs listed above reflect the minimum.

Certifications:	
Durability: (How long can the technology be expected to function under normal operating conditions and still achieve the specified emission reductions?)	Manufacturers claim that the useful life of the technology can be as high as 8,000 to 12,000 service hours if properly maintained. However, this may be reduced when a C-DPF is installed on a poorly maintained engine with leaking fuel injectors, a dirty intake air cleaner, excessive oil consumption and/or lubricating oil in the exhaust. In addition, particulate matter can build up on a C-DPF when an engine does not achieve the proper regeneration temperature for the proper duration (i.e. soot overloading). With this build up, if the C-DPF subsequently begins to regenerate, the collected particulate can oxidize uncontrollably and destroy the particulate filter.
Warranty:	Diesel particulate filters typically carry a 2,000 service hour warranty.
Affect on Engine Warranty: (When possible, identify any impact the technology may have on an engine's warranty.)	The technology imposes additional exhaust flow restrictions of between 20" to 70" of water column or more. In some applications, such as severe cyclic operations, the engine may not generate enough heat to oxidize the collected particulate matter and regenerate the filter. This can lead to soot overloading and backpressures beyond the manufacturer's recommended limit. The specific impact on an original equipment manufacturer (OEM) engine warranty is not known.
Adverse Impacts: **Environmental:**	See "Special Operating Requirements" section below.
Safety:	No known adverse safety impacts.
Special Operating Requirements: (e.g. very-low sulfur fuel or minimum exhaust temperature, etc...)	As is the case with most processes that incorporate catalytic oxidation, the formation of sulfates increases at higher temperatures. Depending on the exhaust temperature and the sulfur content of the fuel, the increase in sulfate particles may offset a portion of the C-DPF's particulate reductions. In addition, sulfur dioxide can counteract the effect of the catalyst material and increase the C-DPF's regeneration temperature. Diesel fuel with a very low sulfur content will maximize the emission reduction capability of this technology.
	C-DPFs must be selected for the specific engine and its associated duty cycle. All engines must be able to maintain the minimum regeneration temperature (which varies by product) for at least 20% - 50% of the engine's duty cycle.
Current Status: (Is the technology commercially available, or is it still under development? How many engines has the technology been installed on, and how long has the technology been in use?)	The technology is commercially available. According to the VERT study [1999], C-DPFs have been installed on several thousand mobile diesel engines. The technology has also been installed on a few stationary diesel engines.

<table>
<tr><td>Other:
(e.g. fuel penalty, reduced product life, weight, affect on engine performance, etc...)</td><td>The size and weight of one manufacturer’s C-DPFs are as follows:
<table><tr><th>HP</th><th></th><th>Diameter</th><th>Length</th><th>Weight</th></tr><tr><td>40</td><td></td><td>8.1"</td><td>18.5"</td><td>17 lb</td></tr><tr><td>100</td><td></td><td>9.6"</td><td>25.5"</td><td>34 lb</td></tr><tr><td>275</td><td></td><td>11.9"</td><td>30.6"</td><td>47 lb</td></tr><tr><td>400</td><td></td><td>15.7"</td><td>34.2"</td><td>87 lb</td></tr><tr><td>1,400</td><td>2@</td><td>20.7"</td><td>38.2"</td><td>151 lb</td></tr></table></td></tr>
<tr><td></td><td>The determination of whether or not a used C-DPF would be considered a “hazardous waste” depends on the material(s) used in the catalytic coating. C-DPFs can be manufactured with catalytic coatings such that the product would not be considered a hazardous waste at the end of its useful life. Further, the Department of Toxic Substances Control currently regulates used automotive catalytic converters as scrap metal as long as the catalyst is left in the converter shell during collection and transport and the converters are going for recycling.</td></tr>
<tr><td></td><td>The ash residue associated with cleaning and maintaining a C-DPF would need to be tested before a hazardous waste determination could be made.</td></tr>
<tr><td>Impacts of Lower Sulfur Diesel Fuel</td><td>Use of diesel fuel with a very low sulfur content will improve the technology’s particulate reduction efficiency. A recent study sponsored by the U.S. Department of Energy (DOE) found that fuel sulfur levels have a significant impact on the ability of C-DPFs to reduce particulate emissions. The study also concluded that fuel sulfur levels of less than 150 ppm are necessary in order to achieve reductions in particulate emission from some C-DPFs.</td></tr>
<tr><td>Comments:
(Address other issues relevant to the use of this technology, including other advantages/disadvantages of using the technology.)</td><td>In addition to reducing particulate emissions, the technology also reduces carbon monoxide and hydrocarbon emissions.</td></tr>
</table>

List of Applications

Technology Name: Catalyzed Diesel Particulate Filter

Facility / Operator	Engine Information	Permit / Registration	Number of Applications	Time in Service	PM Emission Limit	PM Emission Test Results
Sierra Nevada Brewing Company, Inc. Chico, CA	Make: Caterpillar Model: 3412 Application: Generator Fuel Type: Shell Amber 363 DPF: Engelhard DPX	Authority to Construct No. SNB-99-09-AC Issued by Butte County AQMD	Two C-DPFs installed on each of two emergency backup generators.	Recent Installation	0.0584 lb/hr	Emission testing completed in March 2000. Results pending.
New York Metropolitan Transportation Authority[7]	Make: Detroit Diesel Model: Series 50 Application: Transit Bus Fuel Type: Reduced Sulfur Diesel (30 ppm S) DPF: Johnson Matthey CRT	n/a	22	Since February 2000	n/a	Pending
San Diego School District[8]	Make: International Model: 530E Application: School Bus Fuel Type: ARCO EC-D DPF: Engelhard DPX & Johnson Matthey CRT	n/a	5 w/ DPX 5 w/ CRT	Since December 1999	n/a	See List of Emission Test Results

[7] New York MTA Clean Diesel Demonstration Program. As part of this program, the New York MTA intends to evaluate the technology on twenty-five DDC Series 50 and twenty-five DDC 6V92 transit bus engines over a one year period.

[8] Fleet managed by Navistar as part of the ARCO EC-D Demonstration Program.

ARCO Distribution[9]	Make: Cummins Model: M11 Application: Tanker Truck Fuel Type: ARCO EC-D DPF: Engelhard DPX & Johnson Matthey CRT	n/a	5 w/ DPX 5 w/ CRT	Unknown	n/a	See List of Emission Test Results
Ralphs Grocery[10]	Make: Detroit Diesel Model: Series 60 Application: Grocery Truck Fuel Type: ARCO EC-D DPF: Engelhard DPX & Johnson Matthey CRT	n/a	5 w/ DPX 5 w/ CRT	Unknown	n/a	See SAE paper 2000-01-1854 for detailed emission test results.
Swedish Public Transportation Association	Make: Unknown Model: Unknown Application: Transit Bus Fuel Type: Low Sulfur Diesel DPF: Johnson Matthey CRT	n/a	1994: 10 Buses 1996: 1,000 Buses 1999: 2,000 Buses 1999: 1,000 Trucks		Unknwon	Unknown

[9] Fleet managed by ARCO as part of the ARCO EC D-Demonstration Program.

[10] Fleet managed by the National Renewable Energy laboratory (NREL) as part of the ARCO EC-D Demonstration Program.

List of Emission Test Results

Technology Name: Catalyzed Diesel Particulate Filter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
Central Business District (CBD)	Environment Canada, Emission Research and Measurement Division, Report #97-26771-3 (Unpublished)	Nett SF Soot Filter Mfg. by Nett Technologies	Make: Navistar Model: T444 Diesel-Electric Year: Not known BHP: Not known Application: Hybrid Diesel-Electric Transit Bus Configuration: Not known Engine Hours: Not known Fuel Type: Certification Diesel D2 Fuel Use: Not known Exhaust Temp: Not known	 PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	600 rpm Config. 0.036 g/mile 11.16 g/mile 0.12 g/mile 0.04 g/mile	 92% -5% 93% 82%
				  PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	750 rpm Config. 0.027 g/mile 10.62 g/mile 0.13 g/mile 0.13 g/mile	 89% 0% 93% 41%
Special transient cycle designed for a specific wheel loader application.[11]	Emissions Research and Measurement Division, Environment Canada	DPX Particulate Filter Mfg. by Engelhard Corporation	Make: Caterpillar Model: 988 Year: Unknown BHP: 320 Application: Wheel loader Configuration: Unknown Engine Hours: Unknown Fuel Type: 530 ppm S Diesel Fuel Use: 15.8 kg/hr	PM NOx CO HC	17.38 g/hr 290.72 g/hr 112.65 g/hr 9.32 g/hr	0.59 g/hr 224.96 g/hr 35.67 g/hr 2.96 g/hr	97% 23% 68% 68%

[11] Study reported in SAE Technical Paper #1999-01-0110 entitled "The Impact of Retrofit Exhaust Control Technologies on Emissions from heavy-Duty Diesel Construction Equipment."

			Exhaust Temp: Unknown				

ISO 8178 C1	AB Svensk Motor Test Center	CleanDiesel Soot Filter Mfg. by Clean Air Systems	Make: Volvo Model: TD61-G Year: Unknown BHP: 78 hp Application: Mobile Source Configuration: Unknown Engine Hours: Unknown Fuel Type: 50 ppm S MK-1 Diesel Fuel Use (lb/hp-hr): 0.376 / 0.380 Exhaust Temp: Unknown	PM NOx CO HC	0.14 g/bhp-hr 9.55 g/bhp-hr 2.33 g/bhp-hr 0.22 g/bhp-hr	0.02 g/bhp-hr 9.17 g/bhp-hr 0.02 g/bhp-hr 0.01 g/bhp-hr	85% 4% 99% 97%

European Stationary Cycle (OICA)[12]	Engineering Test Services, Charleston, SC	Catalyzed Diesel Particulate Filter	Make: Caterpillar Model: 3126 Year: 1998 or 1999 BHP: 275 horsepower Application: N/A Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: Diesel w/ varying fuel sulfur levels Fuel Use (lb/hp-hr): 0.35 - 0.36 Exhaust Temp: Not Reported	 PM NOx CO HC	<u>3 ppm Sulfur</u> 0.0613 g/hphr 4.94 g/hphr 0.98 g/hphr 0.0542 g/hphr	<u>3 ppm Sulfur</u> 0.0031 g/hphr 4.92 g/hphr 0.06 g/hphr 0.0228 g/hphr	 95% 0% 94% 58%
				 PM NOx CO HC	<u>30 ppm Sulfur</u> 0.063 g/hphr 4.98 g/hphr 0.96 g/hphr 0.056 g/hphr	<u>30 ppm Sulfur</u> 0.0166 g/hphr 4.8 g/hphr 0.02 g/hphr 0.0182 g/hphr	 74% 4% 98% 68%
				 PM NOx CO HC	<u>150 ppm S</u> 0.0708 g/hphr 4.85 g/hphr 1.04 g/hphr 0.0586 g/hphr	<u>150 ppm Sulfur</u> 0.0707 g/hphr 4.87 g/hphr 0.02 g/hphr 0.0105 g/hphr	 0% 0% 98% 82%
				 PM NOx CO HC	<u>350 ppm S</u> 0.0793 g/hphr 4.91 g/hphr 0.94 g/hphr 0.0565 g/hphr	<u>350 ppm Sulfur</u> 0.176 g/hphr 4.69 g/hphr 0.03 g/hphr 0.0194 g/hphr	 -122% 4% 97% 66%

[12] Emission test results reported in "Diesel Emission Control - Sulfur Effects (DECSE) Program, Phase I Interim Data Report No. 4: Diesel Particulate Filters - Final Report," January 2000.

European Stationary Cycle (OICA)[13]	Engineering Test Services, Charleston, SC	Continuously Regenerating Diesel Particulate Filter	Make: Caterpillar Model: 3126 Year: 1998 or 1999 BHP: 275 horsepower Application: N/A Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: Diesel w/ varying fuel sulfur levels Fuel Use (lb/hp-hr): 0.35 - 0.36 Exhaust Temp: Not Reported	 PM NOx CO HC	<u>3 ppm Sulfur</u> 0.0613 g/hphr 4.94 g/hphr 0.98 g/hphr 0.0542 g/hphr	<u>3 ppm Sulfur</u> 0.0032 g/hphr 4.96 g/hphr 0.1 g/hphr 0.0136 g/hphr	 95% 0% 90% 75%
				 PM NOx CO HC	<u>30 ppm Sulfur</u> 0.063 g/hphr 4.98 g/hphr 0.96 g/hphr 0.056 g/hphr	<u>30 ppm Sulfur</u> 0.0176 g/hphr 4.84 g/hphr 0.06 g/hphr 0.0052 g/hphr	 72% 3% 94% 91%
				 PM NOx CO HC	<u>150 ppm S</u> 0.0708 g/hphr 4.85 g/hphr 1.04 g/hphr 0.0586 g/hphr	<u>150 ppm Sulfur</u> 0.0729 g/hphr 4.88 g/hphr 0.06 g/hphr 0.0189 g/hphr	 -3% -1% 94% 68%
				 PM NOx CO HC	<u>350 ppm S</u> 0.0793 g/hphr 4.91 g/hphr 0.94 g/hphr 0.0565 g/hphr	<u>350 ppm Sulfur</u> 0.2025 g/hphr 4.81 g/hphr 0.05 g/hphr 0.0064 g/hphr	 -155% 2% 95% 89%

[13] Emission test results reported in "Diesel Emission Control - Sulfur Effects (DECSE) Program, Phase I Interim Data Report No. 4: Diesel Particulate Filters - Final Report," January 2000.

Federal Test Procedure[14]	Southwest Research Institute, Inc.	One Individual Diesel Particulate Filters	Make: Detroit Diesel Corporation Model: DDC 6067TK60 (DDC Series 60) Year:1998 BHP: 400 hp Application: Heavy Duty Vehicle Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: 368 ppm S Diesel Fuel Use (lb/bhp-hr): 0.393 - 0.401 Exhaust Temp: Approx 100-800°F	PM NOx CO HC	0.073 g/bhp-hr 3.991 g/bhp-hr 1.111 g/bhp-hr 0.115 g/bhp-hr	DPF "A" 0.022 g/bhp-hr 3.960 g/bhp-hr 0.403 g/bhp-hr 0.006 g/bhp-hr	70% 1% 64% 95%
Federal Test Procedure [8]	Southwest Research Institute, Inc.	Two Individual Diesel Particulate Filters	Make: Detroit Diesel Corporation Model: DDC 6067TK60 (DDC Series 60) Year:1998 BHP: 400 hp Application: Heavy Duty Vehicle Configuration: Turbocharged & Aftercooled Engine Hours: Not Reported Fuel Type: 54 ppm S Diesel Fuel Use (lb/bhp-hr): 0.396 - 0.402 Exhaust Temp: Approx 100-800°F	PM NOx CO HC	0.063 g/bhp-hr 3.836 g/bhp-hr 1.200 g/bhp-hr 0.109 g/bhp-hr	DPF "B" 0.008 g/bhp-hr 3.901 g/bhp-hr 0.077 g/bhp-hr 0.005 g/bhp-hr	87% -2% 94% 95%
				PM NOx CO HC	0.063 g/bhp-hr 3.836 g/bhp-hr 1.200 g/bhp-hr 0.109 g/bhp-hr	DPF "A" 0.006 g/bhp-hr 4.062 g/bhp-hr 0.267 g/bhp-hr 0.019 g/bhp-hr	90% -6% 78% 83%

[14] The FTP emission test information was presented in the May 1999 report "Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-Duty Engines to Achieve Very Low Emission Levels" prepared for the Manufacturers of Emission Controls Association by Southwest Research Institute, Inc.

Federal Test Procedure[15]	Southwest Research Institute, Inc.	Continuously Regenerating Trap (CRT) by Johnson Matthey	Make: Detroit Diesel Corporation Model: 6V92TA MUI Year: 1986 BHP: 253 hp Application: Transit Bus Configuration: Turbocharged & Aftercooled Engine Miles: Over 300,000 miles Fuel Type: 2-D Certification Diesel Fuel Use (lb/hr): 64.8 - 66.6 Exhaust Temp: Not Reported Note: Pre-Rebuild w/ CRT & Uninsulated	 PM NOx CO HC	500 ppm S 0.44 g/bhp-hr 10.5 g/bhp-hr 1.0 g/bhp-hr 0.7 g/bhp-hr	100 ppm S 0.03 g/bhp-hr 10.3 g/bhp-hr 0.1 g/bhp-hr 0.1 g/bhp-hr	 93% 2% 90% 86%
City-Suburban heavy Vehicle Route (CSHVR)[16]	West Virginia University	Engelhard DPX Particulate Filter	Make: International Model: 530E Year: 1988 BHP: 275 hp Application: School Bus Configuration: Not Reported Engine Miles: Not Reported Fuel Type: ARCO EC-D Fuel Use (mpg): 4.68/5.09 4.46/4.49 Exhaust Temp: Not Reported	 PM NOx CO HC	Bus 3 0.180 g/mile 18.14 g/mile 2.06 g/mile 0.466 g/mile	Bus 3 0.000 g/mile 16.05 g/mile 0.11 g/mile 0.000 g/mile	Bus 3 100% 11% 95% 100%
				 PM NOx CO	Bus 4 0.192 g/mile 18.11 g/mile 2.45 g/mile	Bus 4 0.000 g/mile 16.45 g/mile 0.18 g/mile	Bus 4 100% 9% 93%

[15] The emission test information was submitted to support Johnson Matthey's application for certification of a Low Sulfur 0.1 g/bhp-hr PM Emissions Reduction Rebuild Kit for all transit engines.

[16] Emission test results reported in SAE paper 2000-01-1854 entitled "EC-Diesel Technology Validation Program Interim Report." (Unpublished)

				HC	0.487 g/mile	0.000 g/mile	100%

City-Suburban heavy Vehicle Route (CSHVR)[17]	West Virginia University	Johnson Matthey CRT Particulate Filter	Make: Cummins Model: M11 Year: 1995-96 BHP: 330 hp Application: Tanker Truck Configuration: Not Reported Engine Miles: Not Reported Fuel Type: ARCO EC-D Fuel Use (mpg): 5.92/5.53 & 4.79/4.95 Exhaust Temp: Not Reported	 PM NOx CO HC	<u>Truck 3</u> 0.510 g/mile 14.05 g/mile 3.25 g/mile 1.026 g/mile	<u>Truck 3</u> 0.015 g/mile 12.49 g/mile 0.49 g/mile 0.068 g/mile	<u>Truck 3</u> 97% 11% 85% 93%
				 PM NOx CO HC	<u>Truck 4</u> 0.613 g/mile 15.26 g/mile 2.53 g/mile 1.456 g/mile	<u>Truck 4</u> 0.037 g/mile 15.37 g/mile 0.15 g/mile 0.153 g/mile	<u>Truck 4</u> 94% -1% 94% 89%

[17] Emission test results reported in SAE paper 2000-01-1854 entitled "EC-Diesel Technology Validation Program Interim Report." (Unpublished)

List of Emission Test Results

Technology Name: Diesel Particulate Filter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
Central Business District (CBD) - Heavy Duty Chassis Dynamometer Emission Test	Environment Canada, Emission Research and Measurement Division, Report #97-26771-3 (Unpublished)	Nett SF Soot Filter Mfg. by Nett Technologies	Make: Navistar Model: T444 Diesel-Electric Year: Not known BHP: Not known Application: Hybrid Diesel-Electric Transit Bus Configuration: Not known Engine Hours: Not known Fuel Type: Certification Diesel D2 Fuel Use: Not known Exhaust Temp: Not known	 PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	600 rpm Config. 0.036 g/mile 11.16 g/mile 0.12 g/mile 0.04 g/mile	 92% -5% 93% 82%
				  PM NOx CO HC	w/ oxidation catalyst 0.318 g/mile 10.66 g/mile 1.78 g/mile 0.22 g/mile	750 rpm Config. 0.027 g/mile 10.62 g/mile 0.13 g/mile 0.13 g/mile	 89% 0% 93% 41%
Special transient cycle designed for a specific wheel loader application.	Emissions Research and Measurement Division, Environment Canada[18]	DPX Particulate Filter Mfg. by Engelhard Corporation	Make: Caterpillar Model: 988 Year: Unknown BHP: 320 Application: Wheel loader Configuration: Unknown Engine Hours: Unknown Fuel Type: 530 ppm S Diesel Fuel Use: 15.8 kg/hr Exhaust Temp: Unknown	PM NOx CO HC	17.38 g/hr 290.72 g/hr 112.65 g/hr 9.32 g/hr	0.59 g/hr 224.96 g/hr 35.67 g/hr 2.96 g/hr	97% 23% 68% 68%

[18] Study reported in SAE Technical Paper #1999-01-0110 entitled "The Impact of Retrofit Exhaust Control Technologies on Emissions from heavy-Duty Diesel Construction Equipment."

ISO 8178 C1	AB Svensk Motor Test Center	CleanDiesel Soot Filter Mfg. by Clean Air Systems	Make: Volvo Model: TD61-G Year: Unknown BHP: 78 hp Application: Mobile Source Configuration: Unknown Engine Hours: Unknown Fuel Type: 50 ppm S MK-1 Diesel Fuel Use (lb/hp-hr): 0.376 / 0.380 Exhaust Temp: Unknown	PM NOx CO HC	0.14 g/bhp-hr 9.55 g/bhp-hr 2.33 g/bhp-hr 0.22 g/bhp-hr	0.02 g/bhp-hr 9.17 g/bhp-hr 0.02 g/bhp-hr 0.01 g/bhp-hr	85% 4% 99% 97%

Control Technology Evaluation

Item	Response
Product Name:	Platinum Plus® DFX Fuel Borne Catalyst + Diesel Particulate Filter
Product Vendor:	Clean Diesel Technologies, Inc.
Vendor Address:	300 Atlantic Street, Suite 702 Stamford, CT 06901-3522
Product Description: (What is the product, and how does it work?)	The technology involves combining the use of a concentrated liquid fuel-borne catalyst (FBC) with an uncatalyzed or lightly catalyzed Diesel Particulate Filter (DPF). The technology reduces particulate matter emissions through catalytic oxidation and filtration. The FBC contains low doses (i.e. 4 - 8 ppm) of platinum and cerium that work together to improve particulate oxidation within the combustion chamber and to lower the temperature at which regeneration occurs within a DPF. While similar to a catalyzed DPF, an FBC enhances DPF regeneration by encouraging better contact between the particulate matter and the catalyst material. The FBC+DPF combination reduces both the carbonaceous and soluble organic fractions of DPM.
Applicability: (What types of engines can the product be installed on?)	The technology can be applied to all stationary and portable diesel engines rated at 5,000 horsepower or less, and can be retrofitted to existing equipment. However, the technology may not be appropriate for applications where an engine and its associated duty cycle do not generate enough heat to oxidize the collected particulate matter and regenerate the filter. For example, the FBC+DPF combination may not be appropriate for engines with exhaust temperatures routinely below 540°F. The FBC manufacturer recommends that an FBC+DPF equipped engine operate such that the exhaust gas temperatures reach 660°F for at least 20 minutes during each 8 hour period of operation.
Manufacturer's Emission Reduction Claim: (What level of emission reduction can be achieved?)	The manufacturer claims that the technology reduces particulate emissions by 70 - 95%.
Emission Reduction Guarantee:	The manufacturer's emission reduction guarantee depends on the engine's baseline emission level.
Certifications: (Identify certifications the product has received, and explain any limits on those certifications.)	Platinum Plus is registered by the U.S. Environmental Protection Agency as a diesel fuel additive.
Emission Test Results: (Summarize emission test results and describe in detail on the attached table.)	**Engine Make/Model** / **Test Cycle** / **PM Reduction** DDC Series 60 / FTP Transient / 57% - 96% Cummins 6BTA / FTP Transient / 95% Cummins N-14 / FTP Transient / 79%

Costs: Initial Retail:	The cost of uncatalyzed or lightly catalyzed particulate filters varies by engine size as follows: $1,300 for a 40 hp engine; $2,000 for a 100 hp engine; $3,500 for a 275 hp engine; $7,000 for a 400 hp engine; and $30,000 for a 1,400 hp engine. The cost of on -board dosing systems is approximately $1,500 - $3,000 for a field retrofit, and $500 - $1,000 if factory installed.
Installation:	$167 - $518 (Assuming 1.5 - 6 hours x $78/hr + $50 in misc parts.)
Operating:	The cost of the FBC is $0.05 - $0.10 per gallon of diesel for bulk treatment or on-board dosing, and $0.10 - $0.15 per gallon of diesel for individually packaged products (quart or gallon containers).
Maintenance:	$156 - $312 (Assuming 2 - 4 hours labor per year.)
Comments:	Diesel particulate filters should be cleaned regularly. Because of higher backpressures and the potential for masking by lube oil ash, ARB staff expects that the periodic maintenance of DPFs will be more frequent and possibly more extensive than that of diesel oxidation catalysts. ARB staff expects that the maintenance costs listed above reflect the minimum.
Durability / Product Life: (How long can the technology be expected to function under normal operating conditions and still achieve the specified emission reductions?)	The manufacturer states that the shelf life of Platinum Plus, when packaged individually, is 24 months, and that its shelf life is 12 - 18 months when mixed with diesel fuel.
	Manufacturers claim that the useful life of a DPF can be as high as 8,000 to 12,000 service hours if properly maintained. However, this may be reduced when a DPF is installed on a poorly maintained engine with leaking fuel injectors, a dirty intake air cleaner, excessive oil consumption and/or lubricating oil in the exhaust. In addition, particulate matter can build up on a DPF when an engine does not achieve the proper regeneration temperature for the proper duration (i.e. soot overloading). With this build up, if the DPF subsequently begins to regenerate, the collected particulate matter can oxidize uncontrollably and destroy the filter. Because the product lowers particulate oxidation temperatures, it can reduce the risk of plugging and uncontrolled regeneration.
Product Warranty:	DPFs typically carry a 2,000 service hour warranty.
Affect on Engine Warranty: (When possible, identify any impact the technology may have on an engine warranty.)	The engine manufacturer should be contacted to determine the specific impact of an FBC+DPF combination on an OEM engine warranty.
Adverse Impacts: **Environmental:**	One FTP emission test suggests that the application of the FBC+DPF combination on an engine equipped with exhaust gas recirculation (EGR) may increase hydrocarbon emissions. See Comments section.
Safety:	There are no known adverse safety impacts.

Special Operating Requirements: (e.g. very-low sulfur fuel or minimum exhaust temperature, etc...)	The FBC manufacturer recommends that an FBC+DPF equipped engine operate such that the exhaust gas temperatures reach 660°F for at least 20 minutes during each 8 hour period of engine operation. In addition, the exhaust temperature should be maintained below 930°F to avoid and/or minimize sulfation.
Current Status: (Is the technology commercially available, or is it still under development? How many engines has the technology been installed on, and how long has the technology been in use?)	The technology is commercially available and has been applied to over 100 city buses in Taiwan, six buses in Hong Kong, and twelve pieces of construction and mining equipment in Germany and Switzerland.
Other: (e.g. fuel penalty, reduced product life, weight, affect on engine performance, etc...)	The available emission test data shows that fuel economy varies from an increase of 2% to a decrease of 3%.
Impacts of Lower Sulfur Diesel Fuel	Although the technology can be applied to existing California diesel fuel formulations with sulfur contents up to 500 ppm, the use of low sulfur diesel fuel should improve the emission reduction efficiency of this technology.
Comments: (Address other issues relevant to the use of this technology, including other advantages / disadvantages of using the technology.)	The FBC+DPF technology appears to have a variable effect on hydrocarbon emissions. When tested on a DDC Series 60 engine equipped with EGR, hydrocarbon emissions increased by approximately 150% although the emissions did not exceed the applicable NOx+HC standard. However, other tests on the same engine without EGR show hydrocarbon reductions of 57% - 82%. When tested on a Cummins N-14 engine, hydrocarbon emissions were reduced by 80%, and when tested on a Cummins 6BTA engine, they were reduced by 64%.
	The manufacturer suggests that, when used with a lightly catalyzed DPF, the FBC+DPF combination can dramatically reduce both hydrocarbon and carbon monoxide emissions. In addition to selecting a precatalyzed DPF, a filter can be lightly catalyzed by conditioning it for 20 hours on FBC treated fuel.

List of Stationary &/or Portable Applications

Technology Name: Platinum Plus Fuel Borne Catalyst + Diesel Particulate Filter

Facility / Operator	Engine Information	Permit / Registration	Number of Applications	Time in Service	PM Emission Limit	PM Emission Test Results
There are no known stationary or portable applications of this technology.	Make: Model: Application: Fuel Type:					

List of Emission Test Results

Technology Name: Platinum Plus Fuel Borne Catalyst + Diesel Particulate Filter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + Diesel Particulate Filter	Make: Detroit Diesel Corporation Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged, Aftercooled, EGR Engine Hours: Not Reported Fuel Type: No. 2 Diesel (368 ppm S) Fuel Use (lb/hp-hr): 0.408 / 0.400 Exhaust Temp: Not Reported	PM NOx CO HC	0.204 g/bhp-hr 2.492 g/bhp-hr 2.528 g/bhp-hr 0.063 g/bhp-hr	0.009 g/bhp-hr 2.312 g/bhp-hr 1.863 g/bhp-hr 0.156 g/bhp-hr	96% 7% 26% -148%
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): 0.403 / 0.409 Exhaust Temp: Not Reported	PM NOx CO HC	0.074 g/bhp-hr 4.051 g/bhp-hr 1.128 g/bhp-hr 0.146 g/bhp-hr	0.014 g/bhp-hr 4.048 g/bhp-hr 0.658 g/bhp-hr 0.049 g/bhp-hr	81% 0% 42% 66%

FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): 0.403 / 0.416 Exhaust Temp: Not Reported	PM NOx CO HC	0.074 g/bhp-hr 4.051 g/bhp-hr 1.128 g/bhp-hr 0.146 g/bhp-hr	0.017 g/bhp-hr 3.969 g/bhp-hr 0.665 g/bhp-hr 0.071 g/bhp-hr	77% 2% 41% 51%
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + *Catalyzed* Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): 0.403 / 0.400 Exhaust Temp: Not Reported	PM NOx CO HC	0.074 g/bhp-hr 4.051 g/bhp-hr 1.128 g/bhp-hr 0.146 g/bhp-hr	0.032 g/bhp-hr 3.953 g/bhp-hr 0.411 g/bhp-hr 0.032 g/bhp-hr	57% 2% 64% 78%
FTP Transient	Southwest Research Institute	Clean Diesel Technology Platinum Plus DFX + *Catalyzed* Diesel Particulate Filter	Make: Detroit Diesel Model: Series 60 Year: 1998 BHP: 400 Application: Heavy Duty Vehicle Configuration: Turbocharged Engine Hours: Not Reported Fuel Type: Diesel Fuel Use (lb/hp-hr): 0.403 / 0.408 Exhaust Temp: Not Reported	 PM NOx CO HC	No. 2 Diesel (350 ppm S) 0.074 g/bhp-hr 4.051 g/bhp-hr 1.128 g/bhp-hr 0.146 g/bhp-hr	CARB Diesel (50 ppmS) 0.013 g/bhp-hr 3.786 g/bhp-hr 0.342 g/bhp-hr 0.018 g/bhp-hr	 82% 7% 70% 88%

FTP Transient	Cummins Engine Company	Clean Diesel Technology Platinum Plus 3100C & Rhone-Poulenc Eolys DPX9 + Diesel Particulate Filter	Make: Cummins Model: Encore 6BTA Year: 1996 BHP: 225 Application: Medium Duty Vehicle Configuration: EGR Engine Hours: 400 hrs Fuel Type: Diesel (350 ppm S) Fuel Use (lb/hp-hr): Not Reported Exhaust Temp: Not Reported	PM NOx CO HC	0.231 g/bhp-hr 2.64 g/bhp-hr 1.44 g/bhp-hr 0.22 g/bhp-hr	0.011 g/bhp-hr 2.14 g/bhp-hr 1.39 g/bhp-hr 0.08 g/bhp-hr	95% 19% 3% 64%
FTP Transient (Hot Start Only)	Southwest Research Institute	Platinum Plus DFX + Diesel Particulate Filter	Make: Cummins Model: N-14 Year: 1998 BHP: 370 Application: Heavy Duty Vehicle Configuration: Not Reported Engine Hours: 1000 Fuel Type: Diesel Fuel Use (lb/hp-hr): 0.393 / 0.391 Exhaust Temp: Not Reported	PM NOx CO HC	0.100 g/bhp-hr 3.869 g/bhp-hr 0.505 g/bhp-hr 0.174 g/bhp-hr	0.021 g/bhp-hr 3.628 g/bhp-hr 0.487 g/bhp-hr 0.035 g/bhp-hr	79% 6% 4% 80%

Control Technology Evaluation

Item	Response
Product Name:	Unikat Combifilter
Product Vendor:	Engine Control Systems
Vendor Address:	165 Pony Drive Newmarket, Ontario Canada, L3Y 7V1
Product Description: (How does it work?)	The product is a diesel particulate filter system which incorporates electrical regeneration. Typically, the particulate filter media consists of either a ceramic wall-flow monolith (e.g. cordierite or silicon carbide) or woven ceramic fibers. The ceramic wall-flow monoliths capture diesel particulate matter primarily through surface filtration, and the woven ceramic fibers capture diesel particulate matter though depth filtration. To prevent plugging of the filter media and to minimize system backpressure, particulate filters must be periodically cleaned. This process of cleaning a particulate filter, termed regeneration, involves the oxidation of the collected particulate matter. Where passive particulate filter systems incorporate catalyst material to lower the temperature at which the collected particulate matter oxidizes, this technology actively regenerates the particulate filter via an electrical heating element. The regeneration is electronically controlled and can be completed in either 30 minutes or 8 hours, depending upon the system chosen.
Applicability: (What types of engines can the product be installed on?)	Individual particulate filter systems are available for diesel engines rated at between 25 and approximately 200 horsepower. Multiple filter elements can be used together for larger applications.
Achieved Emission Reductions:	**Product** / **Test Cycle** / **PM Reduction** Unikat Combifilter / Special Transient / 81% Unikat Combifilter with oxidation catalyst / ISO 8178 / 95%
Emission Reduction Guarantee:	The manufacturer guarantees that their product will reduce DPM emissions by at least 80%.
Costs: Initial Retail:	The initial cost is approximately: $4,450 for a 40 hp engine; $5,780 for a 100 hp engine; $11,690 for a 275 hp engine; $14,000 for a 400 hp engine; and $40,250 for a 1,400 hp engine.
Installation:	For single and dual filter systems: $206 - $518 (Assuming 2 - 6 hours x $78/hr + $50 in misc parts.)

Operating:	For a generator larger than 275 hp, the cost to regenerate the filter is about 1% of the energy produced. The regeneration cost is higher for smaller engine generator sets--up to 7% for a 40 hp engine. In addition, fuel consumption may increase by one to one and a half percent due to additional backpressure.
Maintenance:	$312 for prime engine (Assume 2 cleanings at 2 hours labor each—total of 4 hours labor per year.) and $156 for emergency backup engine every five years (Assume 2 hours labor).
Comments:	The particulate filter systems must be cleaned every 1,000 - 1,500 hours of service to remove accumulated ash. The exact interval is dependent on lube oil consumption.
Certifications:	**Product** **Certification** **Agency** Unikat Combifilter 80% DPM Removal Swiss VERT Program Unikat Combifilter 80% DPM Removal Sweden Environmental Zones--Off-road
Durability / Product Life: (How long can the technology be expected to function under normal operating conditions and still achieve the specified emission reductions?)	Some installations have been in operation over 20,000 hours. The manufacturer does not provide a guarantee for product life.
Product Warranty:	The manufacturer provides a twelve month limited warranty covering manufacturing defects and workmanship. Other warranties may be provided on a case by case basis.
Affect on Engine Warranty: (When possible, identify any impact the technology may have on an engine's warranty.)	The engine manufacturer should be contacted to determine the specific impact of the product on an OEM engine warranty. However, the technology is sized to stay within OEM backpressure limitations.
Adverse Impacts: **Environmental:**	There are no known adverse environmental impacts.
Safety:	There are no known adverse safety impacts.
Special Operating Requirements: (e.g. very-low sulfur fuel or minimum exhaust temperature, etc...)	230V or 400V electrical service is required.

<table>
<tr><td>Current Status:
(Is the technology commercially available, or is it still under development? How many engines has the technology been installed on, and how long has the technology been in use?)</td><td>The technology is commercially available in Europe and Asia and has been employed on captive fleet vehicles such as fork lifts and front end loaders, stationary and mining engines with total installation base of 3,000. According to the manufacturer, the product will be marketed in the United States as of September 1, 2000.</td></tr>
<tr><td>Other:
(e.g. fuel penalty, reduced product life, weight, affect on engine performance, etc...)</td><td>The size and weight of actively regenerated DPF’s are as follows:<table><tr><th>HP</th><th>Diameter</th><th>Length</th><th>Weight</th></tr><tr><td>40 hp</td><td>13.8" - 25.7"</td><td>7.4" - 10.8"</td><td>53 lb - 64 lb</td></tr><tr><td>100 hp</td><td>12.2" - 14.5"</td><td>14.6" - 28.4"</td><td>64 lb - 179 lb</td></tr><tr><td>275 hp</td><td>- -</td><td>- -</td><td>- -</td></tr><tr><td>400 hp</td><td>2 @ 13.8"</td><td>2 @ 20"</td><td>2 @ 86 lb</td></tr></table></td></tr>
<tr><td>Impacts of Lower Sulfur Diesel Fuel:</td><td>The product can be used with California’s existing diesel fuel formulations.</td></tr>
<tr><td>Comments:
(Address other issues relevant to the use of this technology, including other advantages / disadvantages of using the technology.)</td><td>The product regenerates independently of engine exhaust temperature and is suitable for any size engine working under any duty cycle including long idle or light load conditions.</td></tr>
</table>

List of Stationary &/or Portable Applications

Technology Name: Unikat Combifilter

Facility / Operator	Engine Information	Permit / Registration	Number of Applications	Time in Service	PM Emission Limit	PM Emission Test Results
There are no known portable or stationary applications Unikat Combifilter in U.S.	Make: Model: Application: Fuel Type:					
However, a Combifilter system is operational in Welland, Ontario, Canada.	Make: Cummins Model: B5.9 Application: Taylor lift truck Fuel Type: Diesel, unknown S concentration		1	27 Months		

List of Emission Test Results

Technology Name: Unikat Combifilter

Method & Type of Test	Source Test Company	Product Information	Engine Information	Pollutant	Baseline Emissions	Emission Rate w/ Controls	Control Efficiency
Special transient cycle designed for a specific backhoe application.	Emission Research and Measurement Division, Environment Canada[19]	Combifilter Mfg. by Engine Control Systems	Make: Caterpillar Model: 3054DIT Year: 1994 BHP: 84 Application: Backhoe Configuration: Unknown Engine Hours: Unknown Fuel Type: 530 ppm S Diesel Fuel Use: 4.66 kg/hr Exhaust Temp: Unknown	PM NOx CO HC	8.46 g/hr 93.79 g/hr 41.66 g/hr 5.47 g/hr	1.77 g/hr 98.70 g/hr 37.56 g/hr 5.17 g/hr	79% -5% 10% 5%
ISO 8178 C1	AB Svensk Bilprovning	Combifilter with oxidation catalyst Mfg. by Engine Control Systems	Make: Perkins Model: 1004T Year: Unknown BHP: about 44 (for 33.7 kw) Application: Unknown Configuration: Unknown Engine Hours: Unknown Fuel Type: 30 ppm S Diesel Fuel Use: 234-236 g/kwh Exhaust Temp: Unknown	PM NOx CO HC	0.59 g/kwh 13.1 g/kwh 4.71 g/kwh 0.48 g as $CH_{1.85}$/kwh	0.03 g/kwh unk 0.11 g/kwh 0.04 g as $CH_{1.85}$/kwh	95% NA 98% 92%

[19] Study reported in SAE Technical Paper #1999-01-0110 entitled "The Impact of Retrofit Exhaust Control Technologies on Emissions from Heavy-Duty Diesel Construction Equipment."

ISO 8178 C1	AB Svensk Bilprovning	Combifilter with oxidation catalyst Mfg. by Engine Control Systems	Make: Scania Model: Unknown Year: Unknown BHP: 150 (for 114.9 kw) Application: Unknown Configuration: Unknown Engine Hours: Unkown Fuel Type: 30 ppm S Diesel Fuel Use: 223-225 g/kwh Exhaust Temp: Unknown	PM NOx CO HC	0.21 g/kwh 9.65 g/kwh 0.98 g/kwh 0.89 g as $CH_{1.85}$/kwh	0.01 g/kwh 9.68 g/kwh 0.12 g/kwh 0.07 g as $CH_{1.85}$/kwh	95% -0.3% 88% 92%

APPENDIX 2

Potential Cancer Risk Associated
with the Air Dispersion Modeling Results

Air Resources Board staff used the U.S. EPA's Industrial Source Complex-Short Term (ISCST3) air dispersion model to estimate the annual average concentration of particulate matter (PM) emitted from standby stationary diesel-fueled engines of different horsepower ratings. This Appendix identifies the potential cancer risk associated with being exposed to those annual average concentrations. Section I identifies the air dispersion modeling assumptions and inputs. Section II is a series of graphs that illustrate the risk associated with the annual average concentrations of PM. Section III presents our study of the effect of hours of operation on risk.

I. MODELING ASSUMPTIONS AND INPUTS

A. Horsepower ratings
We estimated the diesel PM emissions from diesel-fueled engines with the following horsepower ratings: 100, 200, 300, 400, 500, 750, 1000, and 1400.

B. Emission Factor
0.1 g/bhp-hr

C. Annual hours of operation
Each standby engine operates 50 hours per year for routine maintenance or testing to ensure it is operating properly.

D. Time of Day
Testing or maintenance of standby engines typically occurs during the daytime (i.e., 6 a.m. to 6 p.m.).

E. Hour of Day
The hour of the day that presents the highest concentration of PM emissions is 3 p.m. (See Section H. Meteorological Data for the determination of when this "hour of day" occurs.)

F. Load
Load factor is equal to 100%.

G. Modeling Inputs
See Table 1 below.

Table 1: Standby Diesel Engine Parameters										
					QS	HS	TS		DS	VS
Engine	calculated Fuel Use	Load	Exhaust Flow	Exhaust Flow	emission rate	stack height	stack temp	stack diameter	stack diameter	stack velocity
HP	(gal/hr)	(%)	(dscfm)	(acfm)	g/s	meters	K	inches	meters	m/s
50	2.8	100	124	282	0.00139	3	622	2	0.051	65.7
100	5.2	100	225	514	0.00278	3	622	3	0.076	53.2
200	10.4	100	450	1028	0.00556	3	622	4	0.102	59.9
300	15.5	100	675	1541	0.00833	3	622	5	0.127	57.5
400	20.7	100	900	2055	0.01111	3	622	5	0.127	76.6
500	25.9	100	1125	2569	0.01389	3	622	6	0.152	66.5
600	31.1	100	1350	3083	0.01667	3	622	6	0.152	79.8
700	36.3	100	1575	3597	0.01944	3	622	7	0.178	68.4
750	38.9	100	1688	3854	0.02083	3	622	7	0.178	73.3
800	41.5	100	1800	4111	0.02222	3	622	8	0.203	59.9
900	46.6	100	2025	4624	0.02500	3	622	8	0.203	67.3
1000	51.8	100	2250	5138	0.02778	3	622	9	0.229	59.1
1100	57.0	100	2475	5652	0.03056	3	622	10	0.254	52.7
1200	62.2	100	2700	6166	0.03333	3	622	10	0.254	57.5
1300	67.4	100	2925	6680	0.03611	3	622	11	0.279	51.4
1400	72.6	100	3150	7194	0.03889	3	622	12	0.305	46.6
1500	77.7	100	3376	7707	0.04167	3	622	13	0.330	42.5

1. Stack velocity (VS):

   VS was calculated as follows:

VS = (Actual exhaust cubic feet per minute (acfm) x (1/stack cross-sectional area)

$$\text{Acfm} = \frac{\text{(dscfm)(exhaust temp)}}{\text{(ambient temp)(1-[\% moisture by vol])}}$$

Dscfm (dry standard exhaust cubic feet per minute) calculated using U.S. EPA Method 19 "F" factors (An "F" factor is the ratio of combustion gas volumes to heat inputs.)

Where:

Dscfm = (fuel use)("F" factor)(O_2 correction)(load)(diesel heat content)
Fuel use (gal/hr) = (7100 btu/bhp-hr)(1 gal/137,000btu)(hp)
"F" factor = 9190 dscf/1,000,000 btu
O_2 correction = 20.9/(20.9-10.8)
Load = 100%
Diesel heat content =137,000 btu/gal
Exhaust temperature = 622 K
% moisture by volume = 7.10%

2. Emission rate (QS) = (hp rating)(emission factor)(load)(1hr/3600 sec)

3. Stack height (HS): 3.0 meters

4. Stack temperature (TS): 622 K

5. Stack diameter (DS): Note: stack diameter was interpolated from known engine configurations

6. Setting: Urban

H. **Meteorological Data:** Offsite representative meteorological data from Anaheim (1981) and West Los Angeles (1981) was used. The worst case hour is the hour of the day that results in the highest modeled concentrations of PM. The worst case hour was determined as follows:

1. The worst case hour was assumed to occur between 6 a.m. and 6 p.m.

2. The ISCST3 model was run for a 100-hp engine emitting during the hours of 6 a.m. and 12 noon:

3. Modeling inputs for the 100 hp engine are as follows:
   - QS = 0.00278 g/sec
   - HS = 3.0 meters
   - TS = 622^0K
   - VS = 53.2 m/sec
   - DS = 0.076 meters

4. The fraction of each hour (duration) during which PM emissions occurred was set to be 0.137. (50 emission days/year/365 days/year = 0.137).

5. The ISCST3 model was run for the 100-hp engine emitting from 6 a.m. to 12 p.m. and from 1 p.m. to 6 p.m.

6. The highest annual average concentration value was in the afternoon hours.

7. Next, each afternoon hour was run individually.
   For example, the ISCST3 model was run for the 100-hp engine emitting at 1 p.m.
   This was repeated for the 2 p.m. hour, the 3 p.m. hour, the 4 p.m. hour, the 5 p.m. hour, and finally the 6 p.m. hour.

8. This procedure was completed for the 100-hp engine using the Anaheim and the West Los Angeles (LA) meteorology.

9. This procedure was completed for the 1400-hp engine using the Anaheim and the West Los Angeles (LA) meteorology.

10. Modeling inputs for the 1400 hp engine are as follows:
    - QS = 0.0389 g/sec
    - HS = 3.0 meters
    - TS = 622^0K
    - VS = 46.5 m/sec
    - DS = 0.305 meters

11. The highest annual average concentration value was at the 3 p.m. hour. Therefore, the worst case hour for both the Anaheim and the West LA meteorology data is considered to be the 3 p.m. hour.

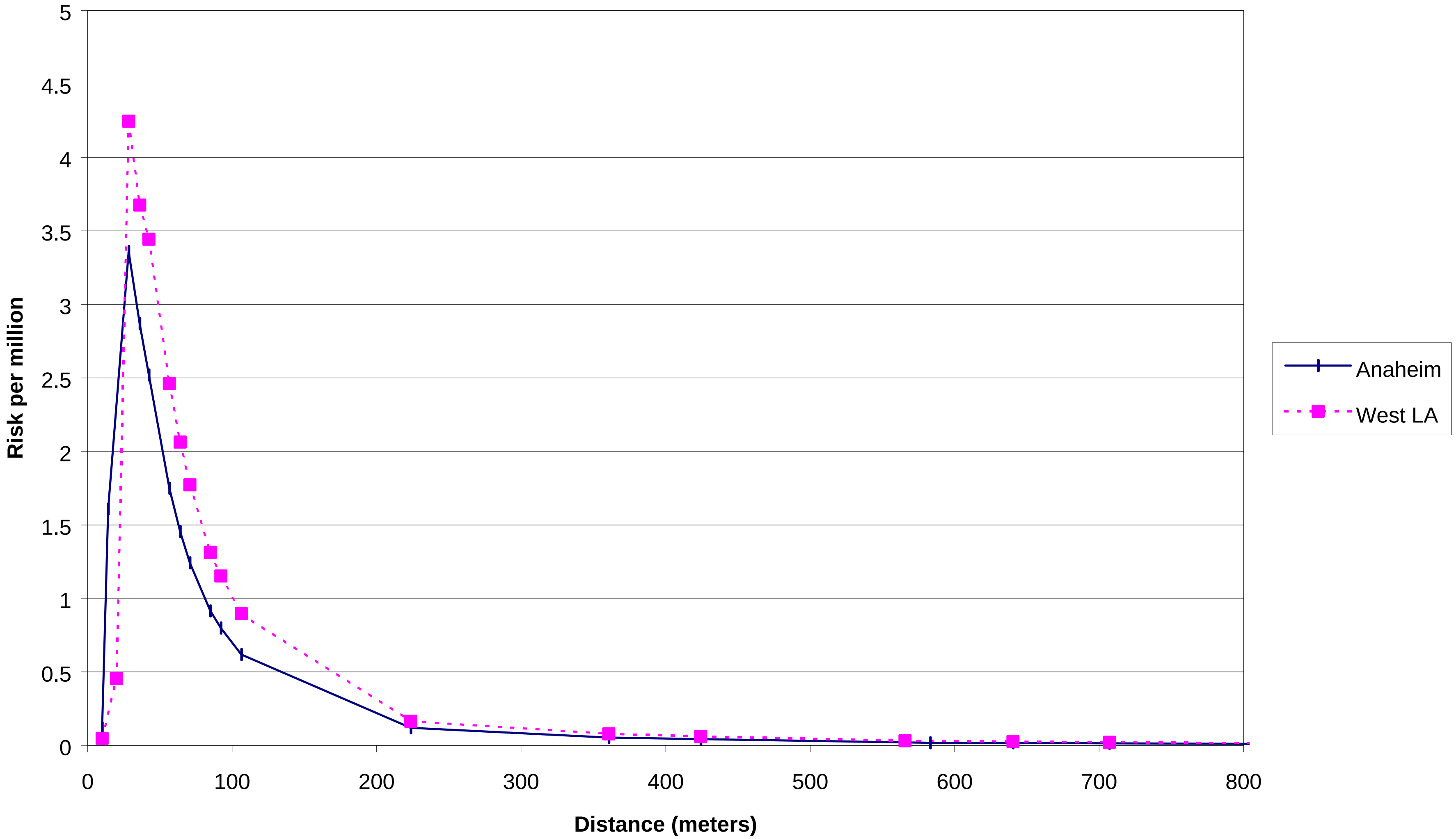
II. RISK CALCULATIONS

The ISCST3 air dispersion model was used to estimate the annual average concentration ($\mu g/m^3$). The potential cancer risk to nearby receptors was estimated by multiplying the annual average concentration by the reasonable unit risk factor (URF) for diesel particular matter, 300×10^{-6} $(\mu g/m^3)^{-1}$.

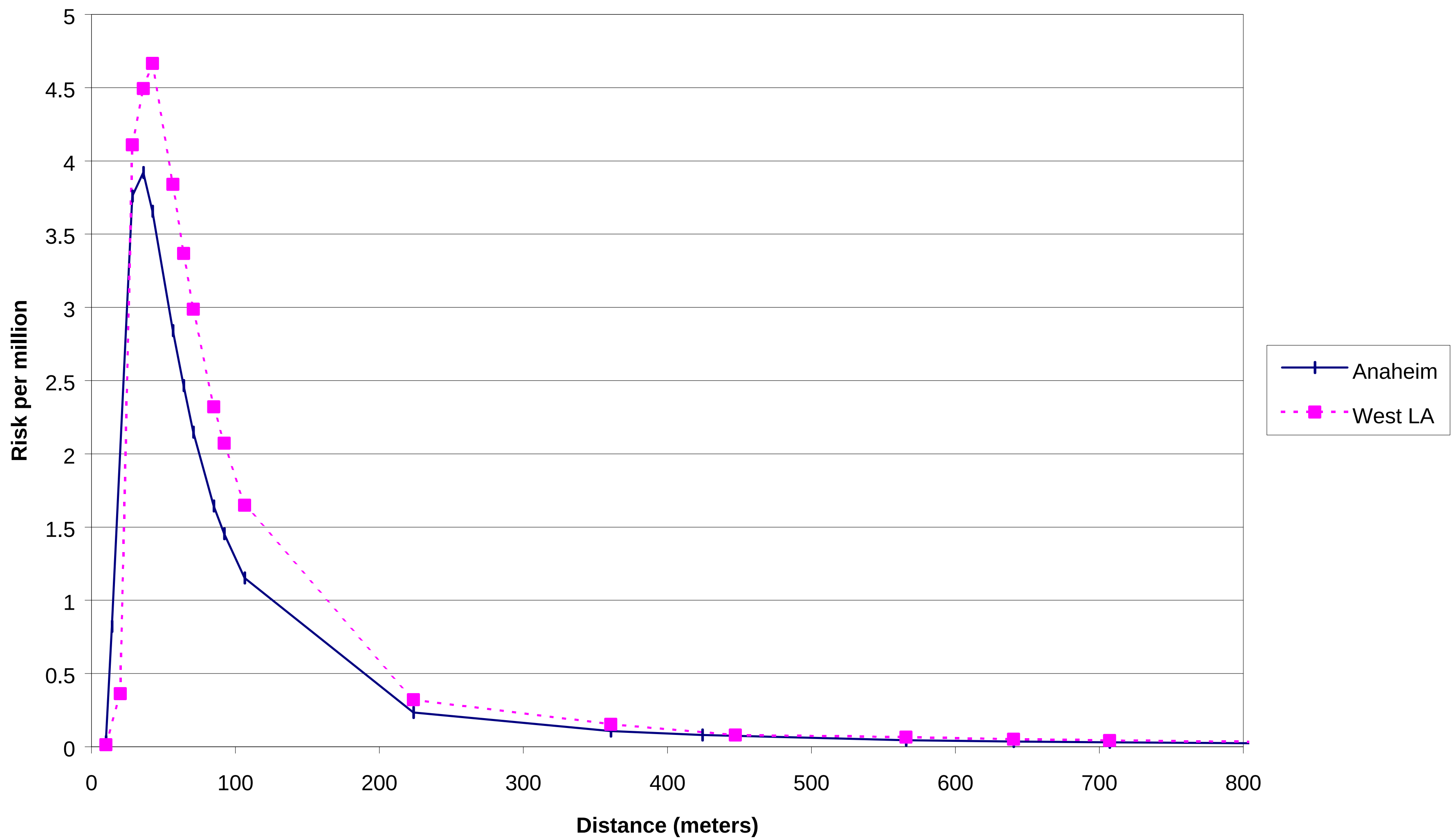
A. **Eight individual engine emission graphs:** Graphs 1 through 8 show the cancer risk at several receptor distances for the eight different horsepower engines modeled (100, 200, 300, 400, 500, 750, 1000, 1400 horsepower).

B. **Summary Graph:** Graph 9 is a summary of graphs 1 through 8. Each engine's maximum cancer risk was plotted at the distance where the highest concentration was modeled to have occurred. In addition to the eight engines, a 50 horsepower engine was modeled using the West Los Angeles meteorology and included on the graph.

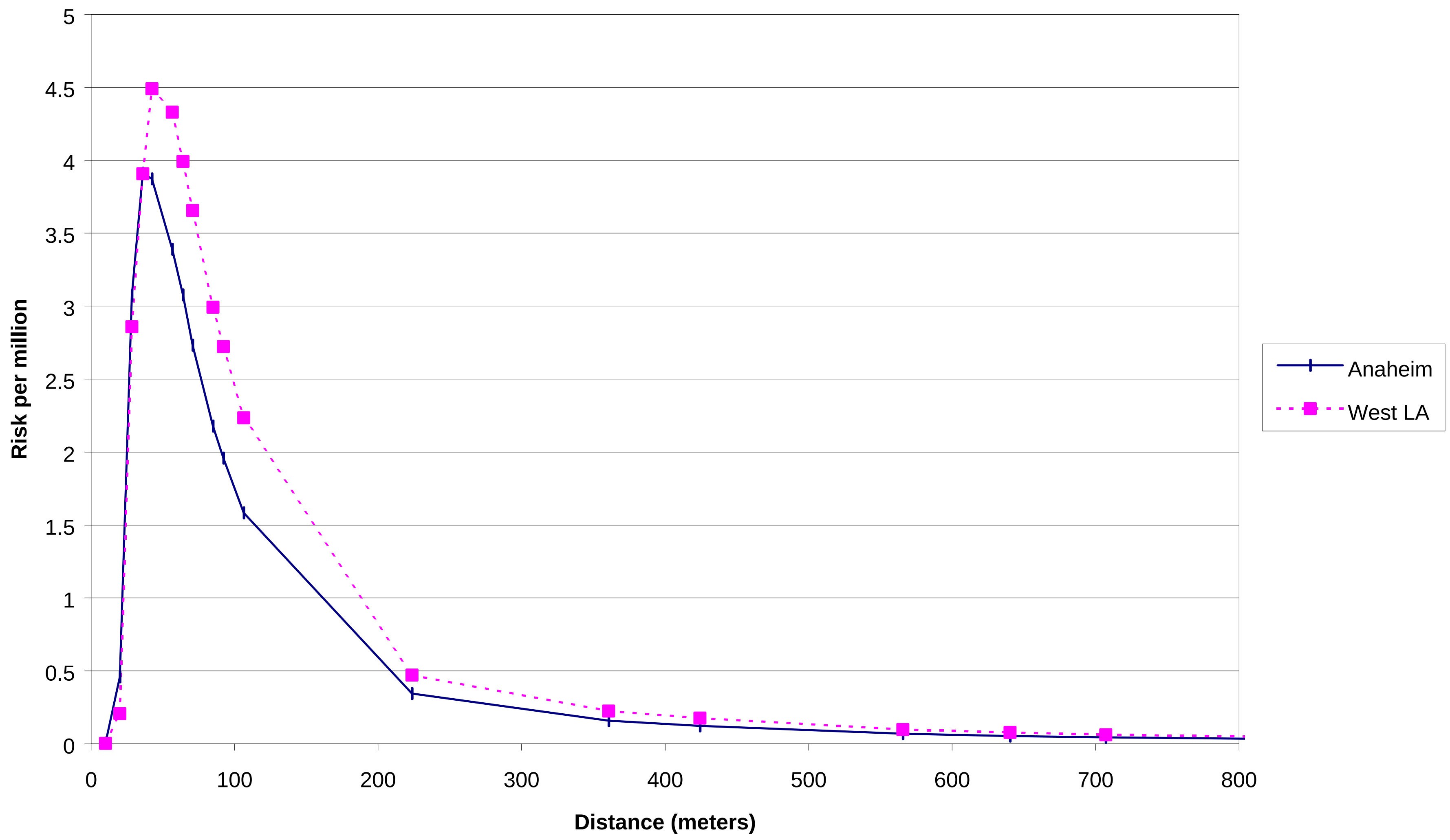
Graph 1: 100 Horsepower Standby Diesel Engine
0.1 g/bhp-hr and 50 Hours/year at 100% Load

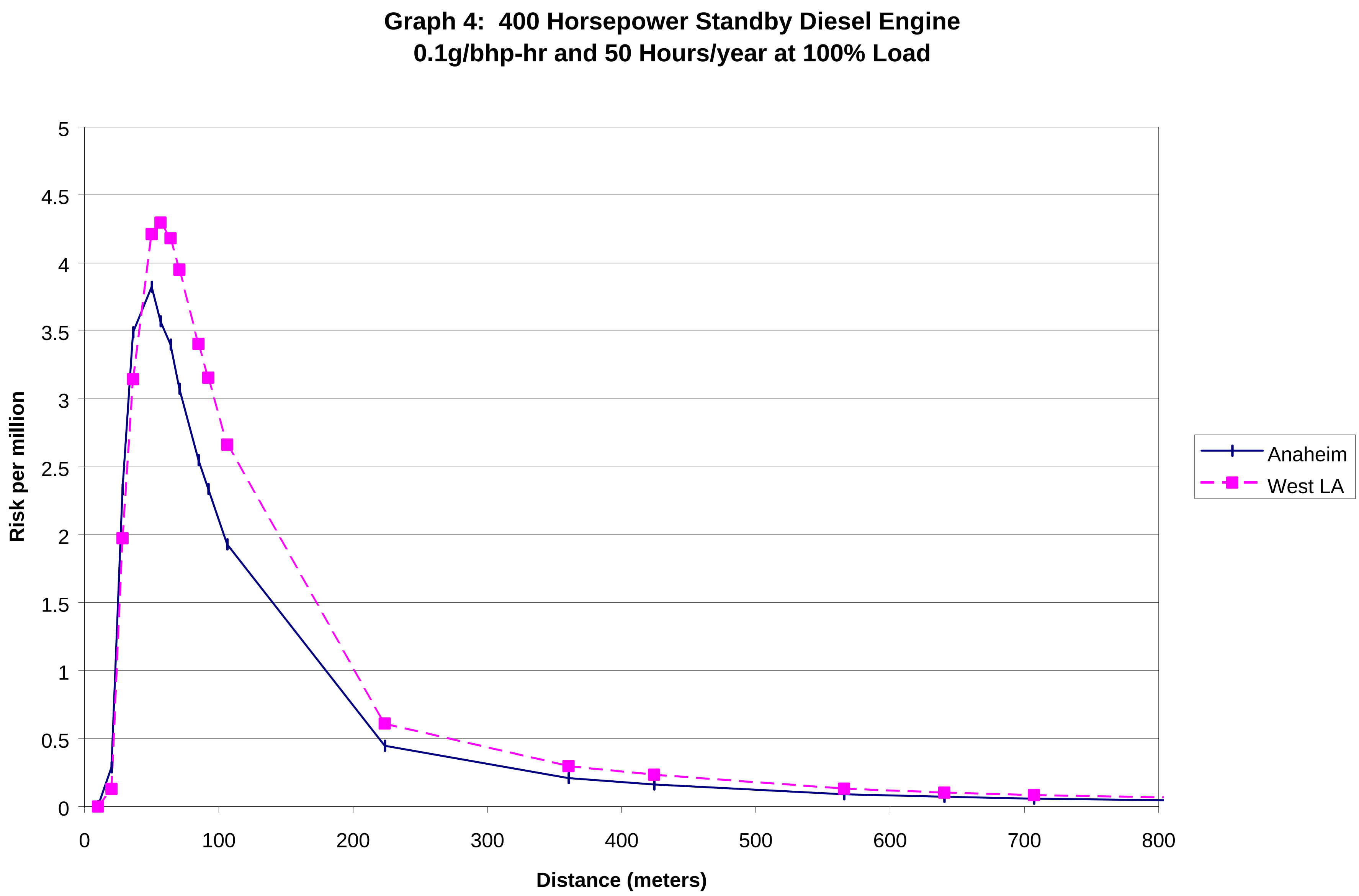


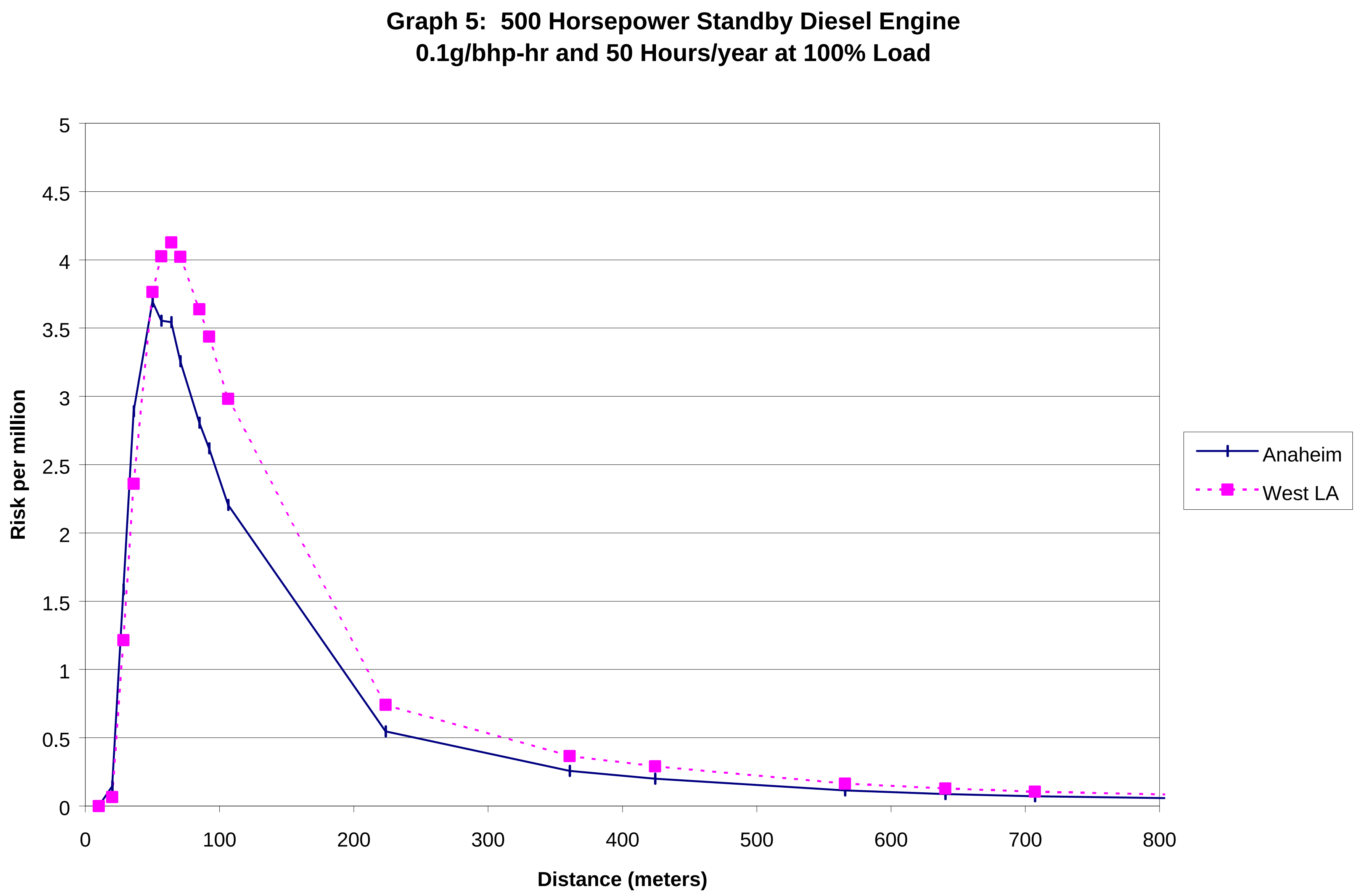
Graph 2: 200 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load



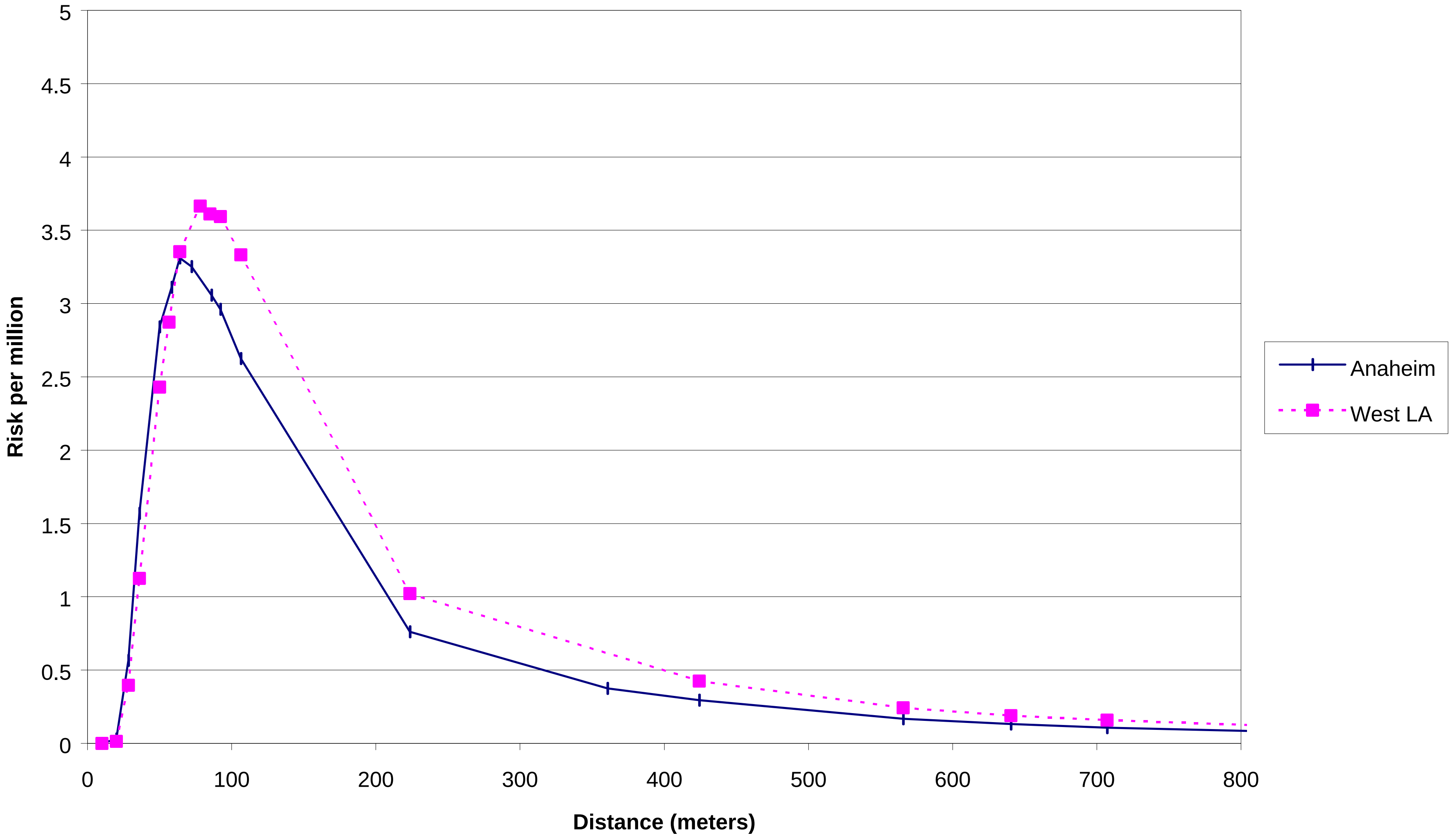
Graph 3: 300 HorsepowerStandby Diesel Engine
0.1 g/bhp-hr and 50 Hours/year at 100% Load

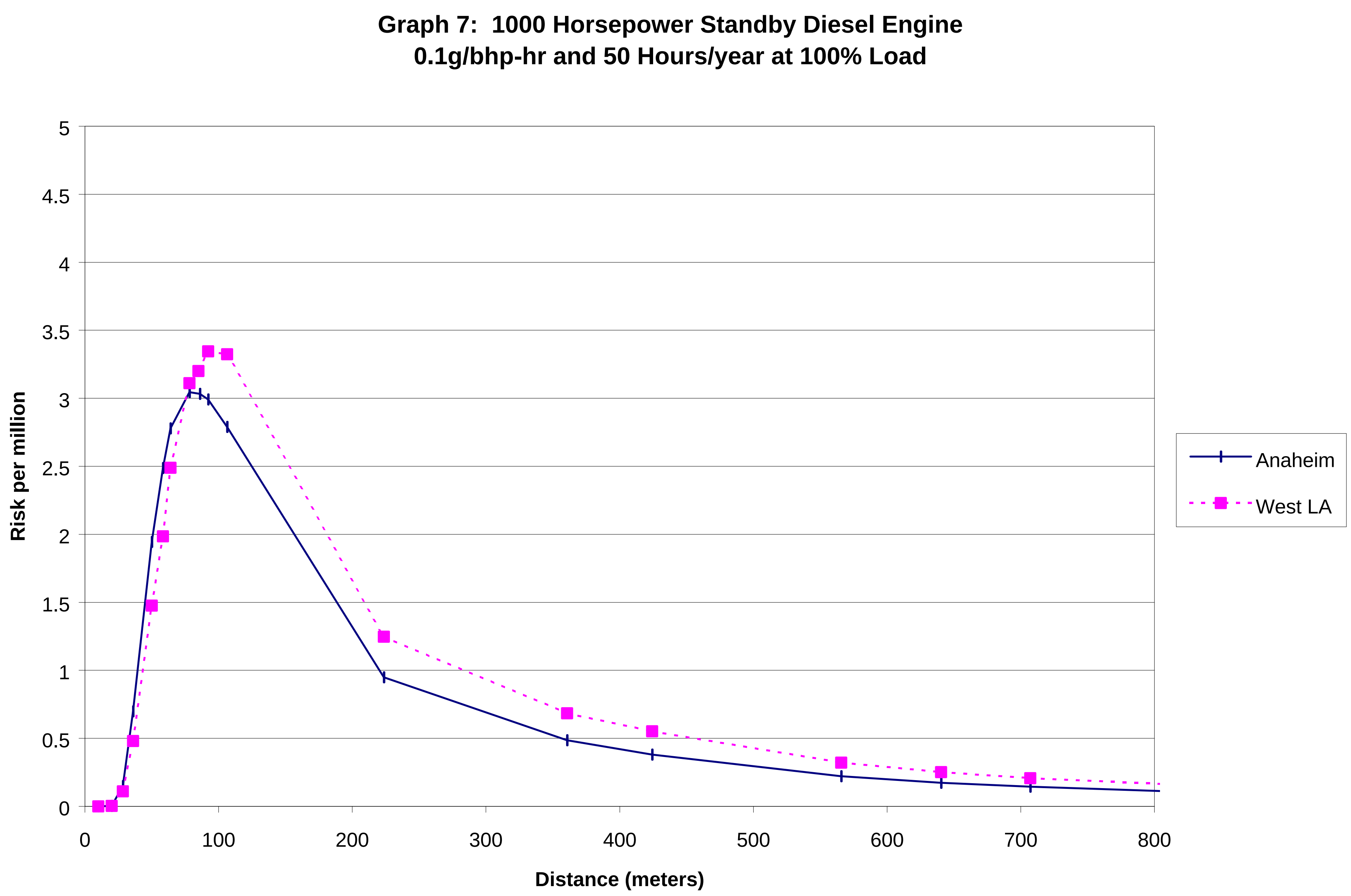



Graph 4: 400 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load
Risk per million
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
100
200
300
400
500
600
700
800
Distance (meters)
Anaheim
West LA

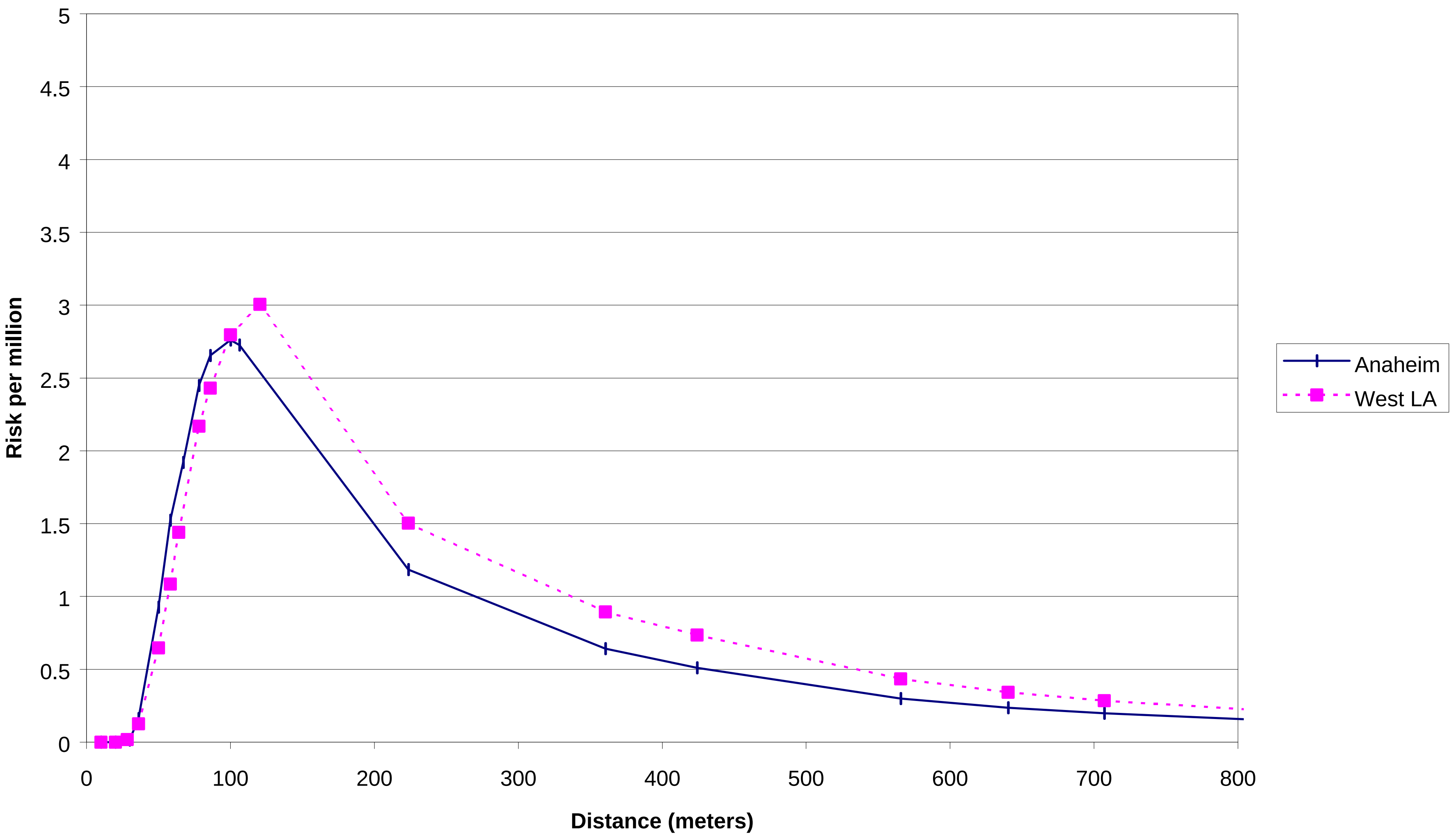

Graph 5: 500 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load
Risk per million
Distance (meters)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
100
200
300
400
500
600
700
800
Anaheim
West LA

Graph 6: 750 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load

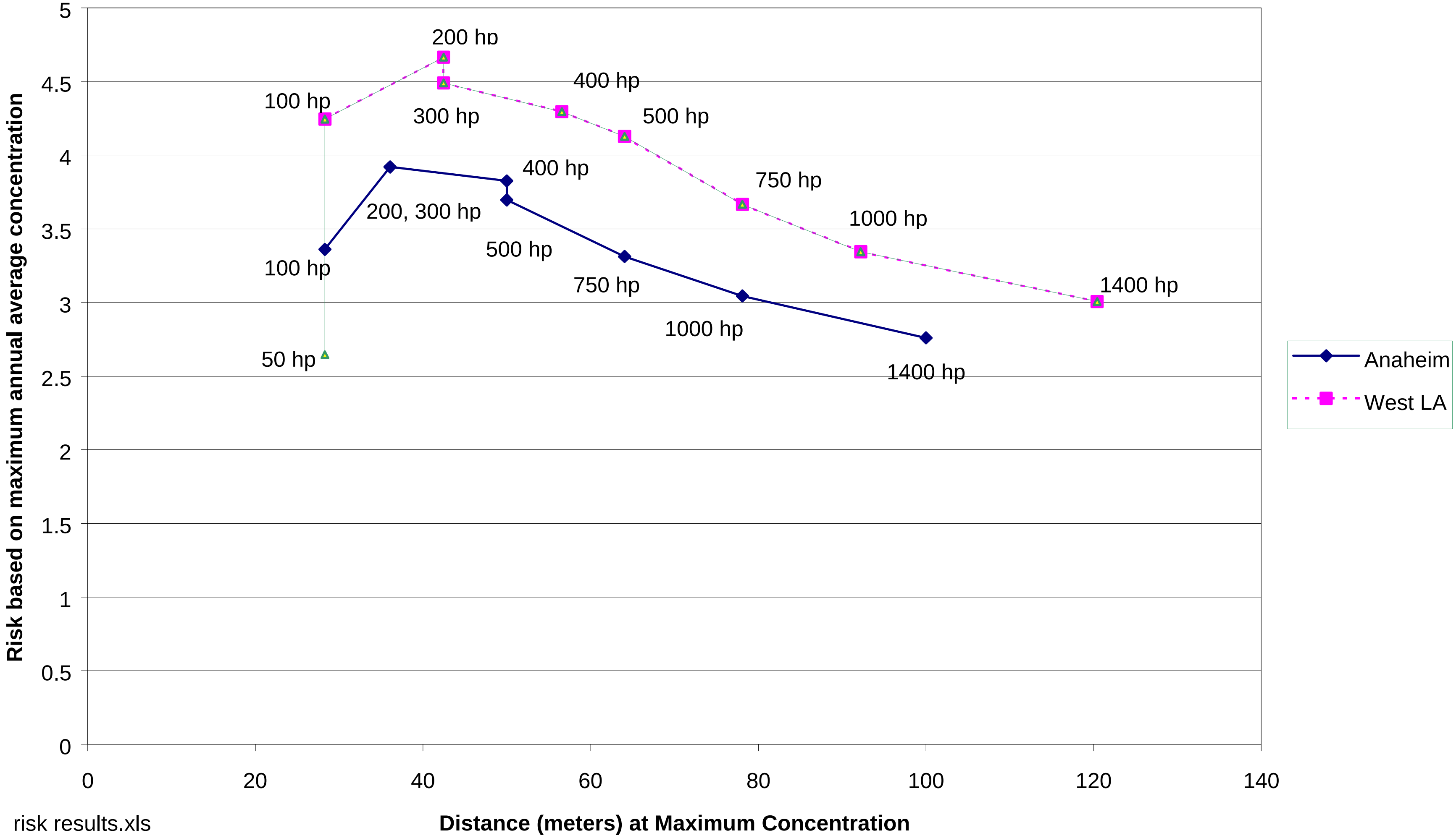



Graph 7: 1000 Horsepower Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load
Risk per million
Distance (meters)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
100
200
300
400
500
600
700
800
Anaheim
West LA

Graph 8: 1400 Horsepower Standby Diesel Engine
0.1 g/bhp-hr and 50 hours/year at 100% Load



Standby Diesel Engine
0.1g/bhp-hr and 50 Hours/year at 100% Load



risk results.xls

III. Hours of Operation

A. Worst Case Modeling

Once we established that the size of the engine did not necessarily drive the risk of cancer, we evaluated increasing hours of operation. Specifically, we evaluated a 500 horsepower engine operating at 50, 100, 300 500 and 1000 hours of operation. We utilized the same modeling inputs as already described for a 500 horsepower engine.

We used the West Los Angeles meteorological data. West Los Angeles meteorology has a predominant wind direction that drives higher risk results. We chose West Los Angeles meteorology as a worst case meteorology.

The fraction of each hour (duration) during which PM emissions occurred was set to be 0.137 for the 50 hour per year scenario only. (50 emission days/year/365 days/year = 0.137). Since the hours of operation increased, so did the fraction of each hour during which PM emissions occurred. The maximum duration input value is 1, for any given hour. The fraction of each hour during which PM emissions occurred is presented in Table 2 below.

Table 2: Fraction of each hour during which PM emissions occurred

A	B	C	D
Hours of Operation per year	Hours of Operation per year/ 365 days per year	B/2	B/3
50	**0.137** (3 p.m.)		
100	**0.274** (3 p.m.)		
300	**0.822** (3 p.m.)		
500	1.37 (greater than 1, so divided between 2 hours)	**0.685** (2 & 3 p.m.)	
1000	2.74 (greater than 2, so divided among 3 hours)		**0.913** (2, 3, & 4 p.m.)

As the hours of operation exceeded multiples of 365, the duration of the emission had to be divided into an additional hour.

To model an engine emitting a total of 500 hours per year requires adding another 0.37 of an hour. Rather than model the emissions with 1 in the 3 p.m. hour and 0.37 in the 2 p.m. hour, we distributed the 1.37 equally between the 2 p.m. and the 3 p.m. hour. Hence, the .0685 input from column C. Likewise, the 1000 hour of operation per year engine required three hours to share the total emission time.

From this exercise, we established that hours of operation does drive the risk of cancer.

B. Uniform Distribution Modeling

Our next exercise was to distribute the emissions across the 12 daytime hours or 6 a.m. to 5 p.m. Our last exercise was to distribute the emissions across all 24 hours of the day. We did this for both the 500 horsepower engine and the 1000 horsepower engine.

The fraction of each hour during which PM emissions occurred is presented in Table 3 below.

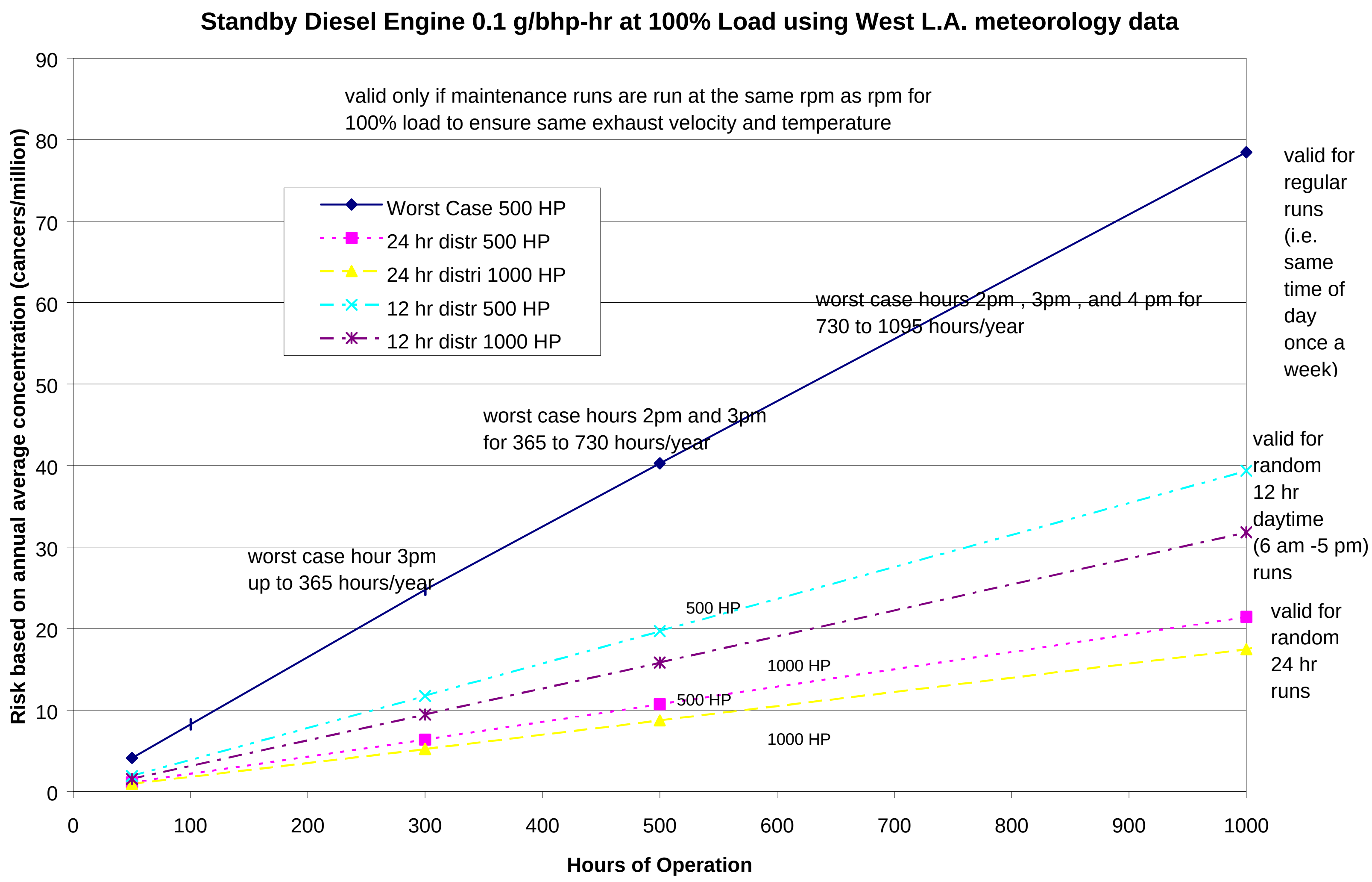
Table 3: Fraction of each hour during which PM emissions occurred

A	B	C	D
Hours of Operation per year	Hours of Operation per year/ 365 days per year	B/12	B/24
300	0.822	0.068	0.034
500	1.37	0.114	0.057
1000	2.74	0.228	0.114
8760	24	X	24

Because the results are linear, i.e. concentration is proportional to emission rate, only one engine was modeled for the 12-hour distribution and only one engine was modeled for the 24-hour distribution. The concentration and risk for the other engine sizes were calculated with the following equation:

$$\frac{\text{X (concentration in } \mu g/m^3)}{\text{Fraction of each hour}} = \frac{\text{known concentration in } \mu g/m^3 \text{ from modeled run}}{\text{fraction of each hour from modeled run}}$$

The results are presented graphically below.


Standby Diesel Engine 0.1 g/bhp-hr at 100% Load using West L.A. meteorology data
valid only if maintenance runs are run at the same rpm as rpm for 100% load to ensure same exhaust velocity and temperature
Worst Case 500 HP
24 hr distr 500 HP
24 hr distri 1000 HP
12 hr distr 500 HP
12 hr distr 1000 HP
worst case hours 2pm , 3pm , and 4 pm for 730 to 1095 hours/year
worst case hours 2pm and 3pm for 365 to 730 hours/year
worst case hour 3pm up to 365 hours/year
valid for regular runs (i.e. same time of day once a week)
valid for random 12 hr daytime (6 am -5 pm) runs
valid for random 24 hr runs
500 HP
1000 HP
500 HP
1000 HP
Risk based on annual average concentration (cancers/million)
Hours of Operation
0
10
20
30
40
50
60
70
80
90
0
100
200
300
400
500
600
700
800
900
1000

APPENDIX 3

Draft Sierra Nevada Brewery Source Test Protocol

Sierra Nevada Brewery Source Test Protocol

Purpose

- Determine the emission of particulate emissions, NO_x, CO, HC, and SO_2 from two 1100 horsepower diesel-fired engines
- Ensure that the emissions meet district permit conditions
- Evaluate the effectiveness of add-on control equipment applied to two 1100 horsepower diesel-fired engines by determining the particulate matter concentration output before and after add-on controls with Method 5.
- Evaluate the change in particulate emissions from using SHELL AMBER 363 vs. CARB Diesel at load
- Evaluate the change in particulate emissions from operating at a weekly level (1 hour /week, no load, 1800 RPMs) vs. operating continuously (with maximum load - facility may rent load bank to simulate load - 1800 RPMs) on CARB Diesel
- Measure sulfur level and other parameters of fuel (SHELL AMBER 363 and CARB Diesel)

Quality Assurance Objectives

Accuracy – include data quality objectives for calibrations, method detection limits, and quality assurance samples

Precision – provide for duplicate analytical samples

Completeness – plan two runs of each test method

Representativeness

- sample at ports away from flow disturbances, sample from a sufficient number of sample points at defined positions across stack traverses, and check that flow is parallel to sample nozzles
- collect sample during normal source operation and collect over as long a period as practical to include any normal variation in operation

Source Test Protocol For
1100 Horsepower Diesel Generators at Sierra Nevada Brewery

	Fuel	**Operation**	**Before or After Control**	**Test Method**	Engine	# of Samples
Particulate Emission Source Test for Continuous (load) Operation for Engine #1 **And CO, O_2, NO_x, and HC Determination** (Remember to take fuel sample to test sulfur content and aromatic HC)						
1.	SHELL AMBER 363	(load)	Before	ARB Method 5 and Method 100 *	#1	2
2.	SHELL AMBER 363	(load)	After Catalyst #1	ARB Method 5 and Method 100	#1	2
3.	SHELL AMBER 363	(load)	After Catalyst #2	ARB Method 5 and Method 100	#1	2
Perform Method 5 and Method 100 for both catalysts (2 outlets).						
Particulate Emission Source Test for Continuous (load) Operation for Engine #2 And CO, O_2, NO_x, and HC Determination						
4.	SHELL AMBER 363	(load)	Before	ARB Method 5 and Method 100 *	#2	2
5.	SHELL AMBER 363	(load)	After Catalyst #1	ARB Method 5 and Method 100	#2	2
6.	SHELL AMBER 363	(load)	After Catalyst #2	ARB Method 5 and Method 100	#2	2
Perform Method 5 and Method 100 both catalysts (2 outlets).						
Comparison of CARB Diesel to Shell Amber 363 Particulate Emissions at Load **And comparison of no load to load on CARB Diesel** **And CO, O_2, NO_x, and HC Determination** (Remember to take fuel sample to test sulfur content and aromatic HC)						
7.	CARB Diesel	(no load)	Before	ARB Method 5 and Method 100 *	#1	2
8.	CARB Diesel	(no load)	After Catalyst #1	ARB Method 5 and Method 100	#1	2
9.	CARB Diesel	(no load)	After Catalyst #2	ARB Method 5 and Method 100	#1	2
Perform Method 5 and Method 100 for both catalysts (2 outlets).						
10.	CARB Diesel	(load)	Before	ARB Method 5 and Method 100 *	#1	2
11.	CARB Diesel	(load)	After Catalyst #1	ARB Method 5 and Method 100	#1	2
12.	CARB Diesel	(load)	After Catalyst #2	ARB Method 5 and Method 100	#1	2
Perform Method 5 and Method 100 for both catalysts (2 outlets).						

***** Measure RPM and brake-hp/hr during tests and take fuel sample for sulfur content and aromatic HC)

Additional Measurements

Measure RPM during tests
Measure brake-horse power/hour during tests
Report results in lbs/hr and g/brake-horse power/hour
Analyze each fuel for sulfur content and aromatic HC

Participants and Stakeholders

ARB
Butte County Air Quality Management District
Sierra Nevada Brewery
Caterpillar
Engelhard

Source Description

1100 horsepower Caterpillar Model 3412 DISTA diesel-fired generator
emissions rating = 0.109 gram/brake horsepower-hour of particulate emissions without control

Control Equipment

Engelhard DPX soot trap (a combination catalytic converter and soot filter)
The catalyst allows the soot to be burned at exhaust temperatures to CO_2 and H_20. Metals collect in the catalyzed filter. Recommend cleaning by vacuuming every 1500 hours and reversing the catalyst when reinstalling.

Sampling Location

Conduct a pre-test site inspection
Conduct a velocity traverse
Verify parallel or non-cyclonic flow per ARB Method 1

Sampling Equipment

As specified in each test method
Must be calibrated and inspected for proper operation prior to use in the field

Testing Dates

March 2000
Sampling and Analytical Procedures

- Sample and Velocity Traverses using ARB Method 1 “Sample and Velocity Traverse for Stationary Sources”
- Stack gas velocity and volumetric flow rate using U.S. EPA Method 2A “Determination of Stack Gas Velocity and Volumetric Flow Rate”
- Moisture content using ARB Method 4 “Determination of Moisture Content in Stack Gases”
- Continuous Emissions Monitoring (CO, O_2, NO_x, HC, and SO_2) using ARB method 100 “Procedures for Continuous Gaseous Emissions Stack Sampling”
- Stack Gas Molecular Weight using ARB Method 3 “Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight”
- Particulate Matter using ARB Method 5 “Determination of Particulate Matter Emissions from Stationary Sources”

Process Parameters

Stack height
Stack temperature
Stack exit velocity (flow rate)
Stack diameter
Inlet, outlet temperature

Building dimensions
Time of day emissions collected
Ambient air temperature
Engine horsepower
Setting (i.e., rural vs. urban)
Receptor distance
Plot plan

APPENDIX 4

Adjustments to the Risk Assessment Methodology and a Discussion of Uncertainty Associated with Risk Assessments

I. Adjustmentsto the Risk Assessment Methodology

A. Use of Exposure Adjustment Factors from Draft OEHHA Risk Assessment Guidelines

This guidance recommends risk assessments be conducted in accordance with the *CAPCOA , Air Toxics "Hot Spots" program, Revised 1992 Risk Assessment Guidelines*, October 1993. However, the OEHHA is currently revising these guidelines and is expected to complete them by July 2000. The revised guidelines should be used when they are finalized.

During the development of this guidance, a number of issues were raised regarding the appropriateness of using some of the risk characterization exposure assessment parameters found in the draft OEHHA Risk management Guidelines prior to their approval. Table 1 identifies the exposure assessment issue and ARB's perspective on the issue.

Table 1: Risk Characterization Exposure Assessment Issues for Consideration in OEHHA's New Risk Assessment Guidelines

Issue	**ARB's Perspective**
Use of Stochastic Analysis Techniques Found in OEHHA's Draft Exposure Assessment Document	Completion of public and peer review process is needed before OEHHA can recommend using probabilistic approaches. Districts may consider stochastic analyses provided as supplemental information to the standard risk assessment information. Permit applicants may provide stochastic analysis as a supplement to the analysis recommended by the existing risk assessment guidelines. Information and comments concerning stochastic analysis should be provided to OEHHA.
Use of Exposure Assessment Parameters Found in OEHHA's Draft Exposure Assessment Document: **Breathing Rate**	Breathing Rate: Completion of public and peer review process is needed before OEHHA can recommend using probabilistic approaches addressed in the draft revised risk assessment guidelines. Districts may consider alternative breathing rate information as supplemental information to the standard risk assessment information Permit applicants may submit alternative information based on breathing rate as supplemental information to the risk assessment.

Table 1: Risk Characterization Exposure Assessment Issues for Consideration in OEHHA's New Risk Assessment Guidelines

Issue	ARB's Perspective
Use of Exposure Assessment Parameters Found in OEHHA's Draft Exposure Assessment Document: **Exposure Duration—Years per Lifetime** **Project Duration More Than Two Years.**	Completion of public and peer review process is needed before OEHHA can recommend using a lifetime exposure duration different than 70 years. Districts may consider alternative lifetime exposure duration information as supplemental information to the standard risk assessment. Permit applicants may submit information based on less than 70 years exposure as supplemental information to the risk assessment.
Exposure Assessment Issue **Exposure Duration—Hours per Day**	The draft risk assessment guidelines do not propose using alternative exposure duration for hours per day exposure. Districts may consider alternative daily exposure duration information as supplemental information to the standard risk assessment information.

B. Use of Site-Specific Exposure Adjustments

In addition to the risk characterization exposure assessment issues addressed in Table 1, there were a number of site-specific risk assessment issues identified during the development of this guidance. Table 2 identifies the site-specific exposure assessment issue and ARB's perspective on the issue.

Table 2: Site-Specific Exposure Assessment Issues to be Addressed by the ARB	
Issue	**ARB Perspective**
Application of an Indoor/Outdoor Correction Factor	Generic use of an indoor/outdoor correction is not appropriate. Methodology is needed to determine appropriate correction factor on a site-specific or situation-specific basis.
Particle Size Correction	Exposure and risk calculations for permitting decisions should be based on the PM_{10} concentration. .
Application of a Wet Deposition Correction Factor	It may be appropriate to include a wet deposition in site-specific risk assessment. Rain will affect dispersion by removing PM from the air. It could also impact the non-inhalation pathway by increasing near-source deposition. Currently, there is no ARB approved methodology for estimating the reduction in PM concentration due to the scavenging of PM via precipitation. However, permit applicants may submit supplemental information to the risk assessment that includes the application of a wet deposition correction factor.
Use of Area-Specific Meteorology	It is appropriate to use area-specific meteorology in risk assessment where available, provided it is appropriate for use. ARB has identified 30 meteorological data sets that are acceptable for use. We would encourage/support a research project to identify additional data sets and/or an analysis to extend the use of existing met data without measurements of key parameters at 30 meter elevations. We strongly recommend district's contact ARB staff to discuss the appropriateness of using meteorological data sets that are not among the 30 sets identified.
Use of Stack-Configuration Information	It is appropriate to adjust for stack configuration in site-specific risk assessment. However, new sources should require vertical stacks without fixed rain caps. ARB will examine existing methodology for modeling non-vertical stacks and stacks with rain caps to determine if it is appropriate for use.
Accounting for Different Dispersion Parameters Based on the Time-of-Day of the Emissions	It may be appropriate to take into consideration the time-of-day of periodic emissions in site-specific risk assessment. Permit applicants can use modeling based on time of day of emissions, but permit needs to have an enforceable time-of-day limit.

Table 2: Site-Specific Exposure Assessment Issues to be Addressed by the ARB (continued)	
Issue	**ARB Perspective**
Application of a Pre-1993 Diesel-Fuel Correction Factor	It is appropriate to use a correction for emission factors developed prior to the introduction of CARB Diesel (1993). ARB recommends using the on-road fuel correction factor. For 94+ engines the correction factor is 0.8972.
Use of Other Dispersion Models	Models other than those listed in the CAPCOA guidelines that reflect state-of-the-science air dispersion modeling techniques should be allowed to be used. ARB will evaluate and authorize the use of new models as they become generally available. If there are specific models not currently authorized for use by ARB, a request for evaluation/authorization should be provided.
Use of Existing Models within 100 meters of Source	Continue to use existing approved models for assessing the exposure/risk within 50 meters of an emission point. Acknowledge model performance more uncertain within 50 meters. ARB is preparing a research proposal for a study to evaluate the applicability of existing models for air concentrations within 50 meters of an emission point. We are seeking additional funding for model validation work. ARB's position is that use of modeling results down to 20 meters is appropriate for most models.
Additional Worker Exposure Correction Factors	Teachers would receive 46/70 correction plus additional site-specific corrections based on scheduled hours of engine operation.
Evaluating future changes in emissions/risk due to current regulatory requirements	For long-term projects, it is appropriate to take into consideration future reductions that are required by regulation or permit. Develop methodology for a time-weighted risk analysis. This is being evaluated as part of the "Risk Characterization Scenarios Analysis".

II. Discussion of the Uncertainty Associated with Risk Assessment

(from the *Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part B, Health Risk Assessment for Diesel Exhaust*, pages 1-13 through 1-14)

Results based on the human data and those based on the animal data are both subject to considerable uncertainty. The strengths and weaknesses of calculating population risks using the human studies (Garshick et al., 1987a; Garshick et al., 1988) and the animal bioassay (Mauderly et al. 1987a; Brightwell et al., 1989; Heinrich et al., 1995; Ishinishi et al., 1986a; Nikula et al., 1995) are summarized in Table 7-6.

The principal uncertainties in using the rat data are their application to humans in terms of response, the choice of dose-response model to extrapolate the risk to environmental concentrations, and the range of dose extrapolation involved.

The principal uncertainties in using the human data are the representativeness of railroad workers for the general population, the choice of the analytical model, and the lack of knowledge of the exposure history of the railroad workers including possible exposure to unknown confounders. The historical reconstruction here is based upon the Woskie et al. (1988b) exposure data for railway workers and the rate of dieselization for U.S. railroads. Using a range of reduced emission assumptions, alternative exposure patterns are considered. This reconstruction takes into account to some degree the likely higher exposure levels in the past. If actual exposures were higher than assumed here, then our estimates of the risk would be lower. If exposures were lower, then the estimated risks would be higher. The range of extrapolation from these estimated occupational exposure levels to the California population-weighted annual average exposure of 1.54 µg diesel exhaust particulate/m^{3} *is not large.*

Table 7-6 Human and Animal Information for Quantitative Estimates of Risk.

Information/Advantage[a]	Animal[b]	Human[c]
Accuracy of exposure estimate in study A++	Numerically precise for rats exposed to automobile exhaust	Uncertain for the railroad workers
Ratio of study exposure to human environmental exposure H++	300	7
Similarity of study exposure to present day exhaust A+	Some uncertainty	Some uncertainty. Uncertain quantitative control for smoking and other pollutants
Model to predict risks at human environmental levels H+	Uncertainty of biological responses such as cell proliferation	Some uncertainty of biological responses such as cell proliferation
Applicability to the human process H++	Much uncertainty in pharmacokinetics and pharmacodynamics	No uncertainty
Consistency of results 0	Consistent with other rat results	Consistent with other human results
Accounting for heterogeneity of human population H+	Uncertainty in ability of the rat model to protect sensitive humans	The railroad study considered only white male workers, who may not be most sensitive
OVERALL CONCLUSION H+	Data quality is strong, but applicability to humans at environmental concentrations is uncertain	Exposure data are weak, but unlikely to greatly overstate or understate risks

[a] Symbols: H for human, A for animal, 0 for neither has the advantage. + and ++ represent the strength of the advantage.

[b] Mauderly *et al*. (1987a), Brightwell *et al*. (1989), Heinrich *et al*. (1995), Ishinishi *et al*. (1986a), Nikula *et al*. (1995)

[c] Garshick *et al*. (1988), Garshick *et al*. (1987a)

The presence or absence of a dose-response threshold is another source of uncertainty. The in vitro and in vivo genotoxicity of diesel exhaust suggests that a non-threshold mechanism for carcinogenesis may be involved. The Moolgavkar quantitative analyses of the rat cancer bioassay did not suggest there was a threshold for the carcinogenicity of diesel exhaust in the rat. In addition, as discussed in the Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part B, Health Risk Assessment for Diesel Exhaust, epidemiological studies have observed increases in the relative risk for lung cancer in association with exposures of the general population to ambient particulate matter. On the other hand, evidence that diesel exhaust particulate matter at high concentrations exceeds pulmonary clearance capabilities and causes chronic inflammation so as to increase production of inflammatory cytokines and cell proliferation may suggest the presence of a threshold. However, at present, the limited evidence available does not allow a threshold value for carcinogenesis to be identified.

On balance, the human data lend more confidence in the prediction of human risks than the data from the rat studies because of the uncertainties of extrapolating from rats to humans, especially in the context of a substantial particle effect. The uncertainties of extrapolating from rats to humans appear to outweigh the uncertainties of using the epidemiological results, namely, the uncertainties of the actual exposure history, modeling, and data selection. The exposure reconstructions bracket the overall exposure and therefore they bracket the risk. The uncertainty in the extrapolation from animal data is difficult to quantify, but is likely to be much greater. Extrapolations of either the animal or human data involve additional sources of uncertainty with respect to both model and data selection.

A number of individuals and organizations have indicated that the epidemiological studies are limited in their application to environmental risk assessment. OEHHA recognizes that the limited exposure information available does contribute to the overall uncertainty of the dose response risk assessment for diesel exhaust based upon the epidemiological findings. However, the overall magnitude of the associated uncertainty is not unduly large. The greater than unusual uncertainty in the exposure estimates is substantially offset by the much smaller than usual range of extrapolation from the occupational exposures of interest to the ambient levels of concern here. The availability of human data obviates the need to use animal data thus avoiding uncertainties of animal-to-human extrapolation. OEHHA provided a tabular range of risk so as to fairly capture the scope of the uncertainty in these analyses.

Appendix 4: References

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